NextEnergy™

Flow Controller 3

Residential Geothermal Loop,
Single and Two-Pump Modules

Installation, Operation &
Maintenance Instructions
97B0015N01
Revision: 05/20/09

Table of Contents

Model Nomenclature

1 2 3 4 5 6 7

A F C | G | 2 | C | 1

Accessory Flow Controller (digits 1–3)

Vendor/Series (digit 4)
G = Current Series

# of Pumps (digit 5)
1 = 1 Pump
2 = 2 Pumps

Valves (digit 6)
B = Brass 3-way valve with double O-ring fittings
C = Composite 3-way valve with double O-ring fittings

Pump Model # (digit 7)
1 = UP26-99
2 = UP26-116 (AFC2B2 only)

Rev.: 08/01/06D

GENERAL INFORMATION

FLOW CONTROLLER DESCRIPTION
The AFC series Flow Controller is a compact, easy to mount polystyrene cabinet that contains 3-way valves and pump(s) with connections for flushing, filling and pumping residential geothermal closed loop systems. The proven design is foam-insulated to prevent condensation. Full flow service valves minimize pressure drop. One or two Grundfos pump models UP26-99 or UP26-116 are available for a variety of unit flow rates and loop layouts. Flow Controllers are designed for systems that require water flow rate of up to 20 U.S. GPM [1.26 l/s]. Unit and loop connections are designed for double o-ring adaptor fittings for a variety of connection types (fusion, threaded, barbed, cam). Pumps are 230VAC, 60Hz. An attractive gray polystyrene cabinet with black pump(s) provides an esthetically pleasing enclosure for pump(s) and valves.

Safety
Warnings, cautions and notices appear throughout this manual. Read these items carefully before attempting any installation, service or troubleshooting of the equipment.

DANGER: Indicates an immediate hazardous situation, which if not avoided will result in death or serious injury. DANGER labels on unit access panels must be observed.

WARNING: Indicates a potentially hazardous situation, which if not avoided could result in death or serious injury.

CAUTION: Indicates a potentially hazardous situation or an unsafe practice, which if not avoided could result in minor or moderate injury or product or property damage.

NOTICE: Notification of installation, operation or maintenance information, which is important, but which is not hazard-related.

Figure 1a: Flow Controller Dimensions (1 Piece Cabinet)

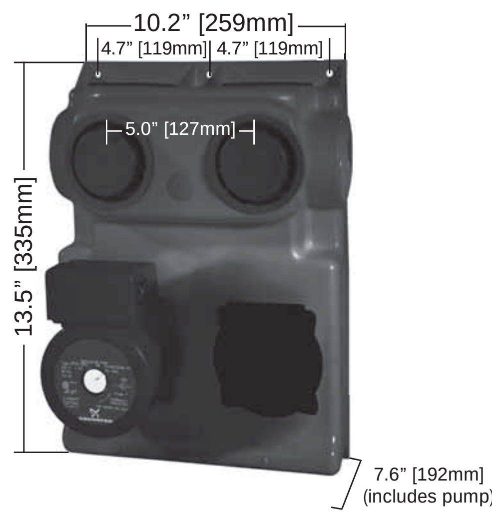
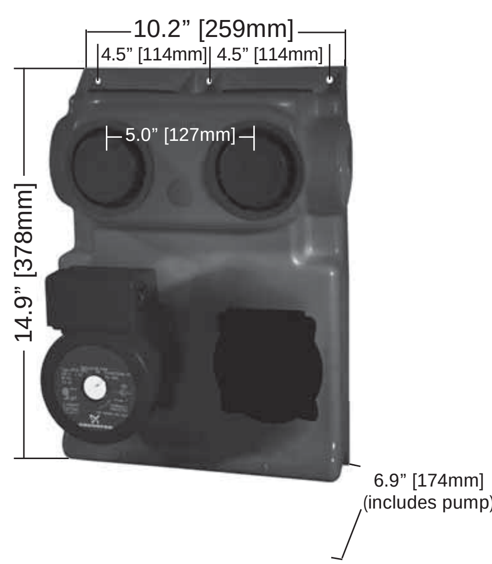


Figure 1b: Flow Controller Dimensions (2 Piece Cabinet)



Flow Controller Mounting

⚠ CAUTION! ⚠

CAUTION! The following instructions represent industry accepted installation practices for closed loop earth coupled heat pump systems. Instructions are provided to assist the contractor in installing trouble free ground loops. These instructions are recommendations only. State/provincial and local codes MUST be followed and installation MUST conform to ALL applicable codes. It is the responsibility of the installing contractor to determine and comply with ALL applicable codes and regulations.

General
The Flow Controller should be located as close to the unit as possible to limit the length of rubber hose kit and thus its associated pressure drop. In general the Flow Controller can be mounted in any orientation with the exception of when the pump shafts are in a vertical position as when it is laid flat on the floor or any similar position. The controller is typically mounted in one of three locations (see below). Be certain that there is adequate access to all required flush ports and valves before mounting.

Stud Wall - Mounting on stud wall with or without drywall can be accomplished by using the two supplied lag bolts through the top and bottom center holes directly into the studs as shown in Figure 2.

Side of Unit - Mounting on the side of the unit can be accomplished by using the four self-drilling screws directly into the sheet metal access panels or cabinet as shown in Figure 3. Be careful not to puncture any internal refrigerant piping or other components with the screws. It should be remembered that heat pump access will be limited in this mounting position.

Concrete wall - Mounting onto a concrete wall can be accomplished by using 4-1/4” [10.8 cm] ‘Tapcon’ screws (supplied by others) directly into the concrete wall.

NOTICE! - Flow Controller pumps must be mounted so that the pump shaft is always in a horizontal position. In other words, Flow Controller must always be mounted in a vertical position (not on it’s back or mounted to the ceiling). Pump damage will occur with pump shaft in a vertical orientation.

Figure 2: Mounting Flow Controller on Stud Wall

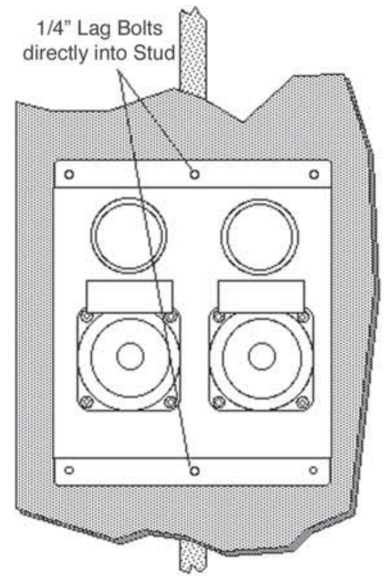
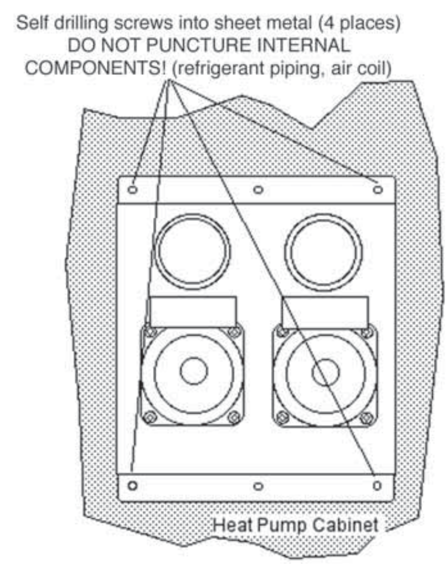


Figure 3: Mounting Flow Controller on the Side of Unit



Piping Installation

Piping Installation
The Flow Controller features Double O-ring fittings for flexible and easy installation. Table 1 illustrates the connection options available for Flow Controllers with polystyrene cabinets. Avoid using 3/4" [19.1mm] piping on flows greater than 6 gpm [0.38 l/s]. Pressure drop in piping systems should be calculated to insure adequate flow through unit. All piping should be properly insulated with closed cell insulation of 1/2" [12.7 mm] wall thickness. Table 2 shows the insulation requirements for typical piping materials. Piping insulation should be glued and sealed to prevent condensation using closed cell insulation glue. The swivel connectors on the Flow Controller are designed to be hand tightened only. Connections between the Flow Controller and adapters are sealed with double o-rings fittings shown in figure 4.

Loop side piping is typically polyethylene piping directly into the Flow Controller. Connection to the Flow Controller

Figure 4: Double O-Ring Adapters

AFC4I

AFC4C

AFC4T

AFC5F

AFC6F

Hose Kit
AHK5EC

Table 1: Flow Controller Connection Materials

To	Fittings	Part #
Polyethylene (PE) Fusion	1-1/4" PE Fusion x Double O-ring	AFC6F
PE Fusion	1" PE Fusion x Double O-ring	AFC5F
PE Barb	1-1/4" insert barb x Double O-ring[1]	AFC6I
PE/Rubber Hose Barb	1" insert barb x Double O-ring[1]	AFC4I
Cam Adapter	Male Cam adapter x Double O-ring[2]	AFC4C
Copper Sweat or PVC Glue	1" MPT x Double O-ring[3]	AFC4T

NOTES:
1. Use two all-stainless hose clamps per connection. One set of 1" insert barb x Double O-ring adapter fittings is included with AHK5EC hose kit.
2. One set of cam adapters required for connection to flush cart hoses. Cam connectors should be left with the installed Flow Controller for future service. Most flush carts will have female cam fittings that will mate to these fittings.
3. Adapters from 1" MPT to copper sweat or PVC glue provided by others.

Table 2: Typical Piping Insulation Materials

Piping Material	Insulation Description
1" Hose Kit	1-3/8" [34.9 mm] ID - 1/2" [12.7 mm] wall
1" IPS PE	1-1/4" [31.8 mm] ID - 1/2" [12.7 mm] wall
1-1/4" IPS PE	1-5/8" [41.3 mm] ID - 1/2" [12.7 mm] wall
2" IPS PE	2-3/8" [60.3 mm] ID - 1/2" [12.7 mm] wall

Piping Installation

can be accomplished by a fusion or barbed fitting as shown in Table 1. In multiple Flow Controller systems such as multifamily housing, PE can also be used on the heat pump side. Polyethylene is the only acceptable material for pipe buried in the ground.

Unit side piping is typically connected using the hose kit (AHK5EC), which contains all fittings necessary for connection between the Flow Controller and the unit as shown in Figure 5.

In multiple unit systems, PE piping materials can be used to 'tee' more than one unit into the Flow Controller. It is recommended that a hose kit still be used at the end of the PE piping run to facilitate ease of installation and service of the units as shown in Figure 6. Insulate all exposed piping. Plastic to metal threads should not be used due to their leakage potential.

The APSM pump slaving module can be used to allow a single Flow Controller to be controlled by two heat pumps as shown in figure 7a.

Figure 5: AHK5EC Hose Kit Typical Detail

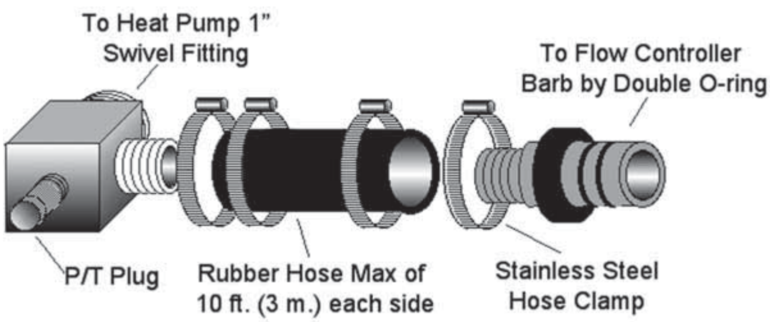
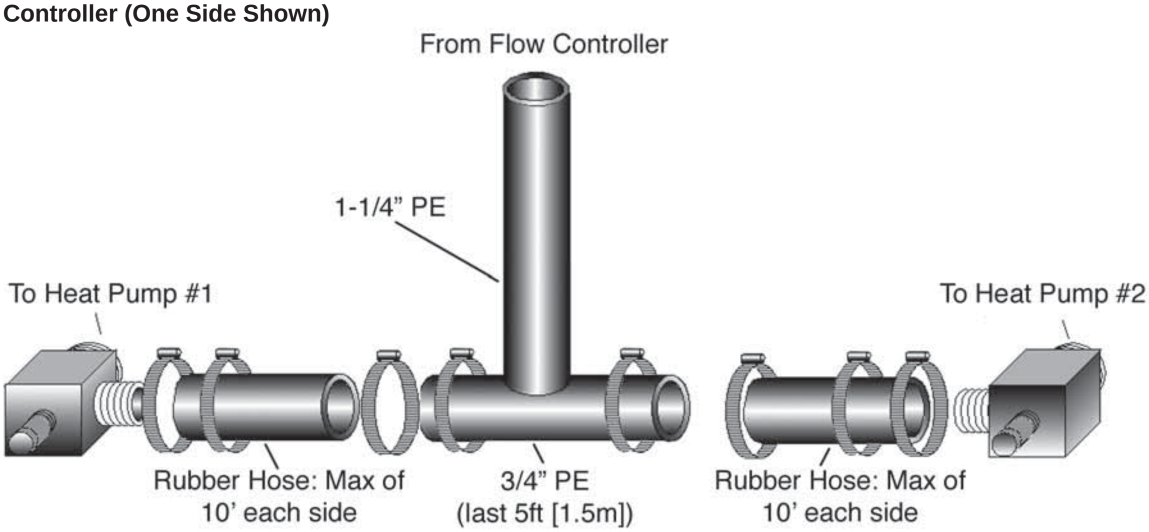
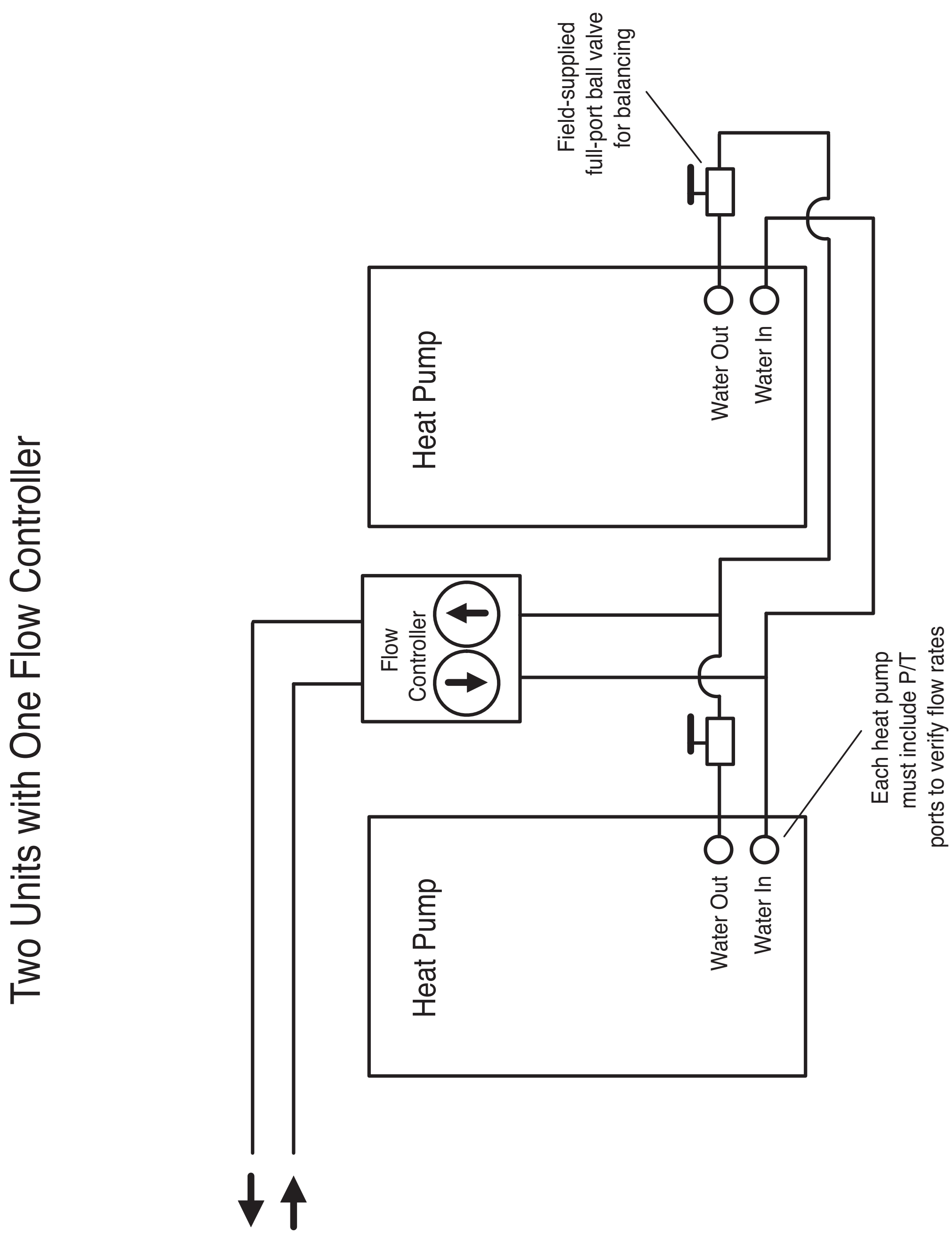


Figure 6: Two Units Utilizing One Flow Controller (One Side Shown)



Piping Installation

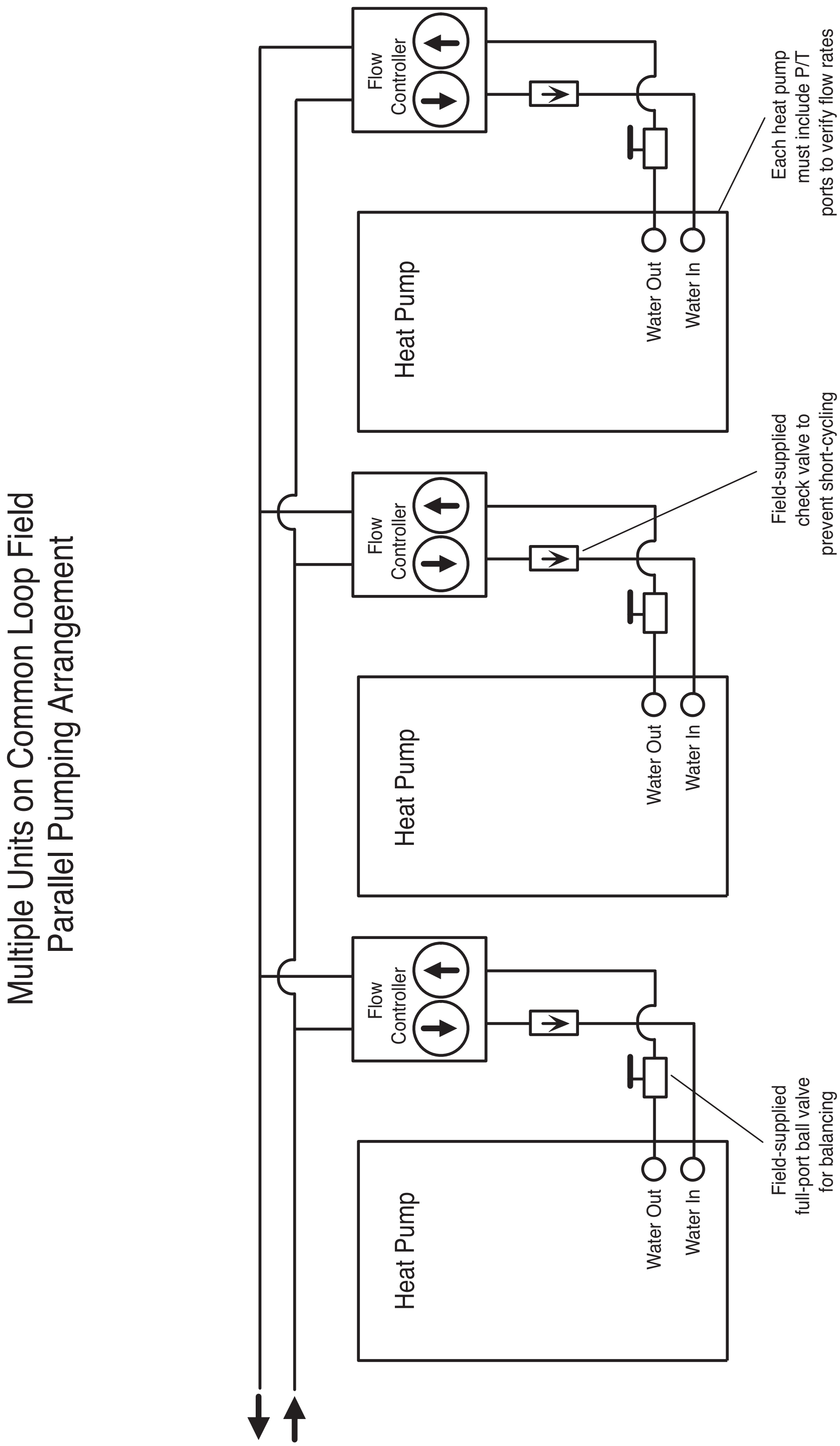
Figure 7a: Parallel Unit Piping 1



NOTES:
1. Piping is shown schematically. Actual pipe diameter and layout must be determined before installation.
2. Pressure drop calculation must be made to verify that Flow Controller can deliver design flow rate when both units are operating.
3. Hose kits of longer than 10 ft. (3 meters) one way should not be used. PE pipe or SCH80 PVC should be used for lengths greater than 10 ft. (3 meters).
4. All units must include P/T ports for flow rate measure and balancing.
5. Use optional field-installed loop pump slaving relay (part # APSM) to wire both units to the Flow Controller pump(s).

Piping Installation

Figure 8b: Parallel Unit Piping 2



NOTES:
1. Piping is shown schematically. Actual pipe diameter and layout must be determined before installation.
2. Pressure drop calculation must be made to verify that parallel pumping arrangement provides enough head to deliver design flow rate to each unit when all units are operating.
3. Flow Controller should be mounted close enough to unit to maintain short (approx. 10 ft., 3m) hose kit from Flow Controller to unit.
4. All units must include P/T ports for flow rate measure and balancing.

Flow Controller Electrical Wiring

⚠ WARNING! ⚠

WARNING! To avoid possible injury or death due to electrical shock, open the power supply disconnect switch and secure it in an open position during installation.

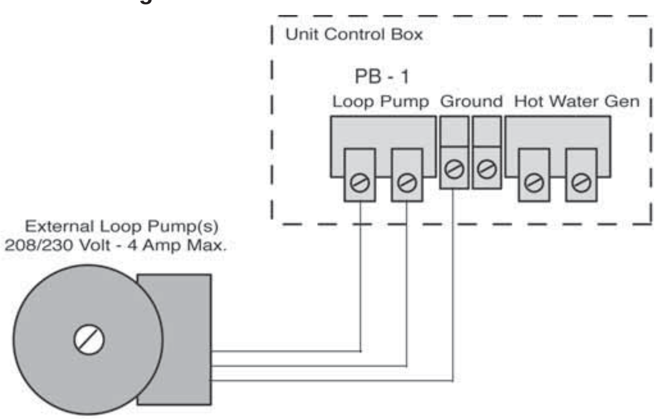
⚠ CAUTION! ⚠

CAUTION! Use only copper conductors for field installed electrical wiring. Unit terminals are not designed to accept other types of conductors.

Power wiring to the Flow Controller should conform to all applicable codes. Figure 8a illustrates the wiring required between the heat pump and Flow Controller. Note the Flow Controller is available only in 230V single phase voltage. Pumps are fused through a pair of circuit breakers in the unit control box. See electrical table for Flow Controller characteristics.

The pump slaving module is designed to allow two units to share one Flow Controller. The module is mounted in a NEMA enclosure, which is designed to be mounted on the Flow Controller or on the outside of the unit. Wire the pumps and unit as shown in figure 8b.

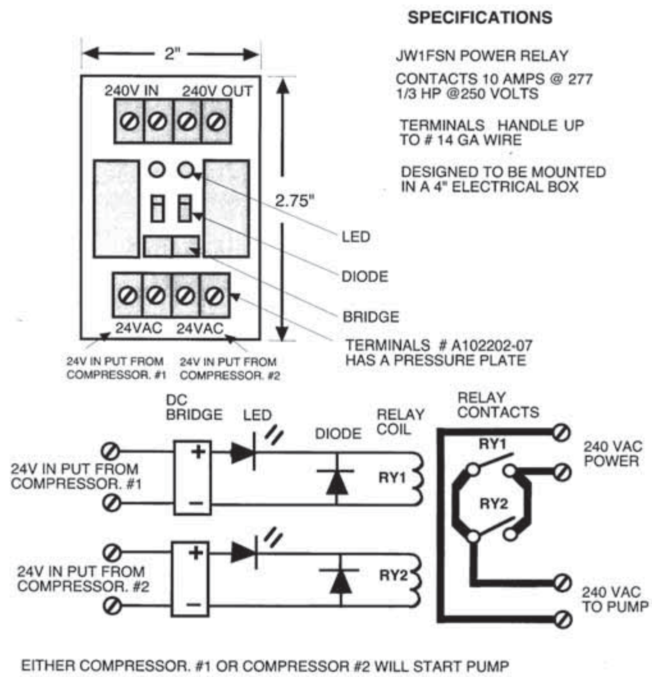
Figure 8a: Heat Pump / Circulator Pump Power Wiring



Electrical Table

Model	Qty	Volts	Amps	HP
UP26-99	1	230	1.07	1/6
UP26-99	2	230	2.14	1/3
UP26-116	2	230	3.50	1/3

Figure 8b: Wiring for Two Units Sharing One Flow Controller (APSM Module)



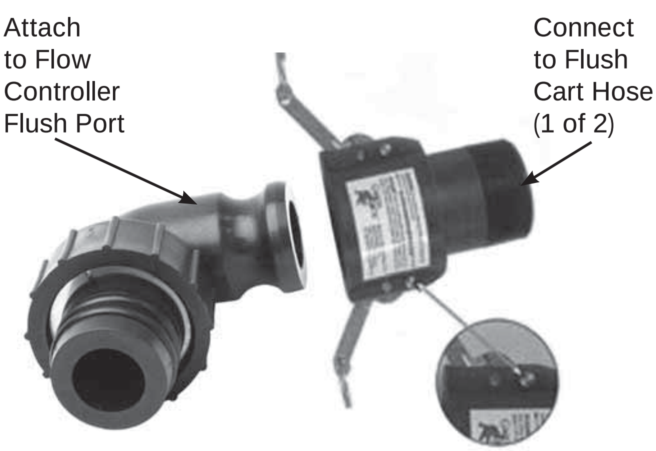
Flushing the Earth Loop

Once piping is completed between the unit, Flow Controller and the ground loop, final purging and charging of the loop is needed.

A flush cart (at least a 1.5 hp [1.1kW] pump) is needed to achieve adequate flow velocity in the loop to purge air and dirt particles from the loop itself. Antifreeze solution is used in most areas to prevent freezing. All air and debris must be removed from the earth loop piping system before operation, Flush the loop with a high volume of water at a high velocity (2 fps [0.6 m/s] in all piping), both directions using a filter in the loop return line, of the flush cart to eliminate debris from the loop system. See charts 6a through 6e for flow rate required to attain 2fps [0.6 m/s]. The steps below must be followed for proper flushing.

Figure 9a: Typical Cleanable Flush Cart Strainer (100 mesh [0.149mm])

Figure 9b: Cam Fittings for Flush Cart Hoses

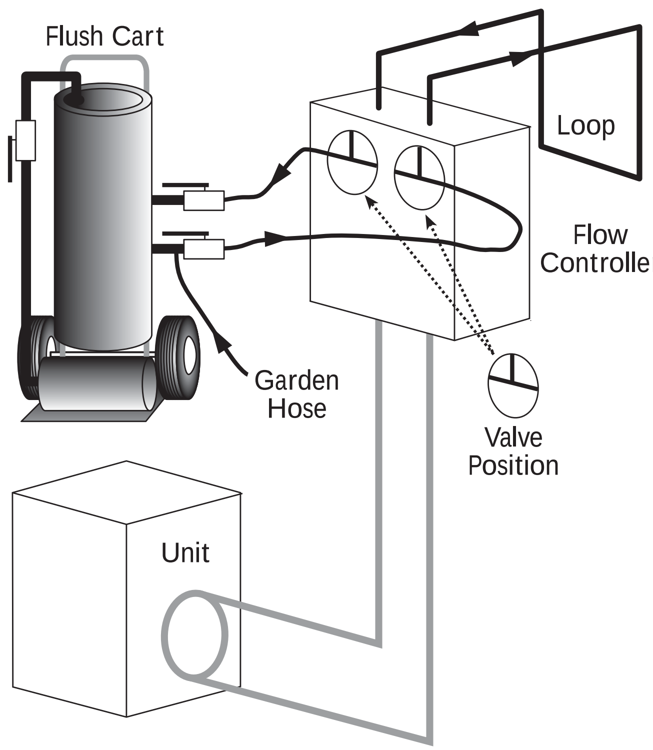


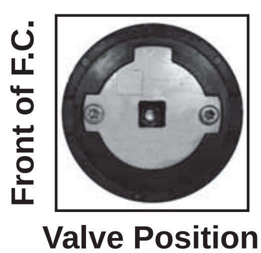
⚠ WARNING! ⚠

WARNING! Disconnect electrical power source to prevent injury or death from electrical shock.

NOTICE: A hydrostatic pressure test is recommended on ALL piping, especially underground piping before final backfill per IGSHPA and the pipe manufacturers recommendations.

Figure 10a: Valve Position A - Loop Fill

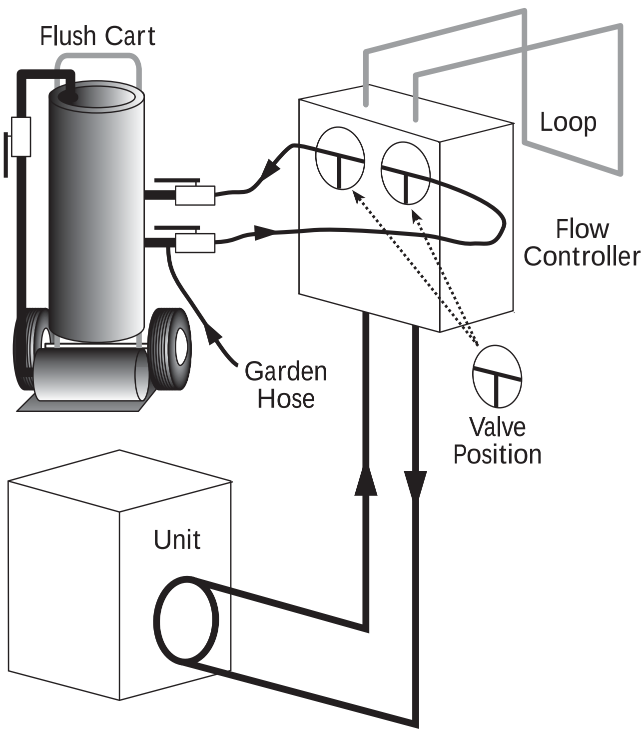




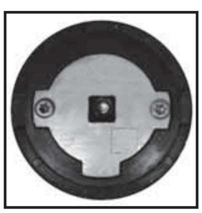
Fill loop with water from a garden hose through flush cart before using flush cart pump to ensure an even fill and increase flushing speed. When water consistently returns back to the flush reservoir, switch to valve position B.

Flushing the Earth Loop

Figure 10b: Valve Position B - Unit Fill



Front of F.C.



Valve Position

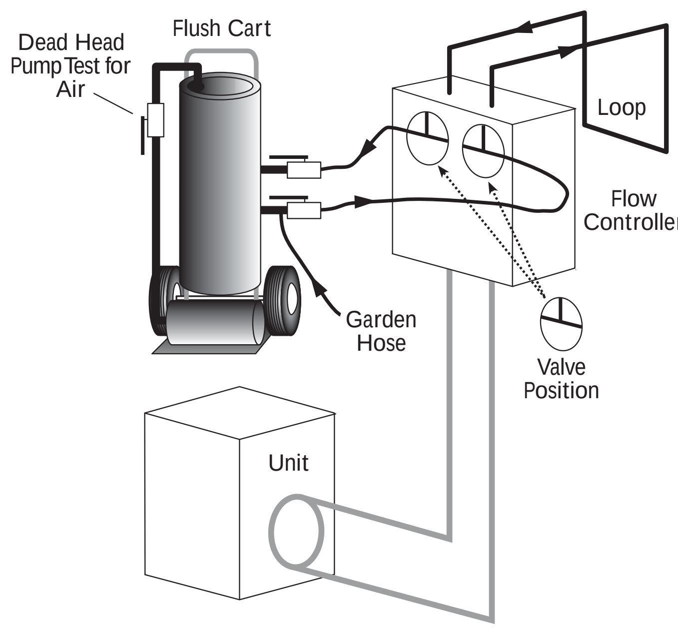
This position should be switched while filling to fill the unit heat exchanger and hose kit. The position should be maintained until water consistently is returned into the flush reservoir.

Switch to valve position C. The supply water may be shut off and the flush cart turned on to begin flushing. Once the flush reservoir is full, do not allow the water level in the flush cart tank to drop below the pump inlet line or air can be pumped back out to the earth loop. Try to maintain a fluid level in the tank above the return tee so that air can not be continuously mixed back into the fluid. Surges of 50 psi [345 kPa] can be used to help purge air pockets by simply shutting off the return valve going into the flush cart reservoir. This process 'dead heads' the pump to 50 psi [345 kPa]. To dead head the pump until maximum pumping pressure is reached, open the valve back up and a pressure surge will be sent through the loop to help purge air pockets from the piping system. Notice the drop in fluid level in the flush cart tank.

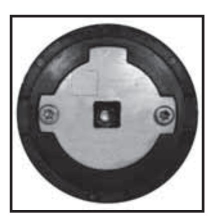
If all air is purged from the system, the level will drop only 1 - 2 inches [2.5 - 5 cm] in a 10" [25.4 cm] diameter PVC flush tank (about a half gallon [1.9 liters]) since liquids are incompressible. If the level drops more than this level, flushing should continue since air is still being compressed in the loop fluid. Do this a number of times. When the fluid level is dropping less than 1-2" [2.5 - 5 cm] in a 10" [25.4 cm] diameter tank, the flow can be reversed.

NOTICE: Actual flushing time require will vary for each installation due to piping length, configuration, and flush cart pump capacity. Most closed loop installations will require at least 20 minutes or longer.

Figure 10c: Valve Position C - Loop Flush



Front of F.C.

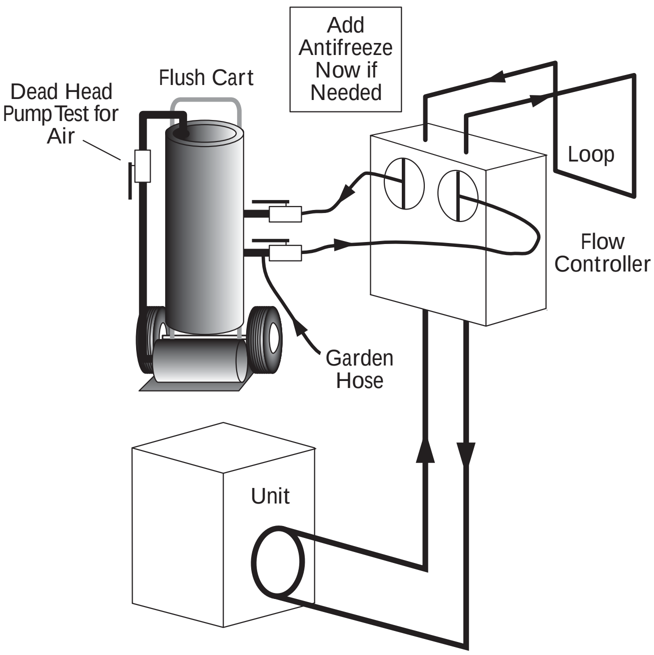


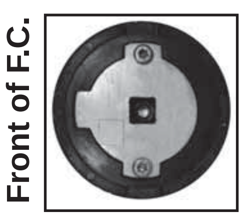
Valve Position

Flushing the Earth Loop

Move valves to position D. By switching both valves to this position, water will flow through the loop and the unit heat exchanger. Finally, the dead head test should be checked again for an indication of air in the loop. Fluid level drop is your only indication of air in the loop. Antifreeze may be added during this part of the flushing procedure; see antifreeze section for details.

Figure 10d: Valve Position D - Full Flush

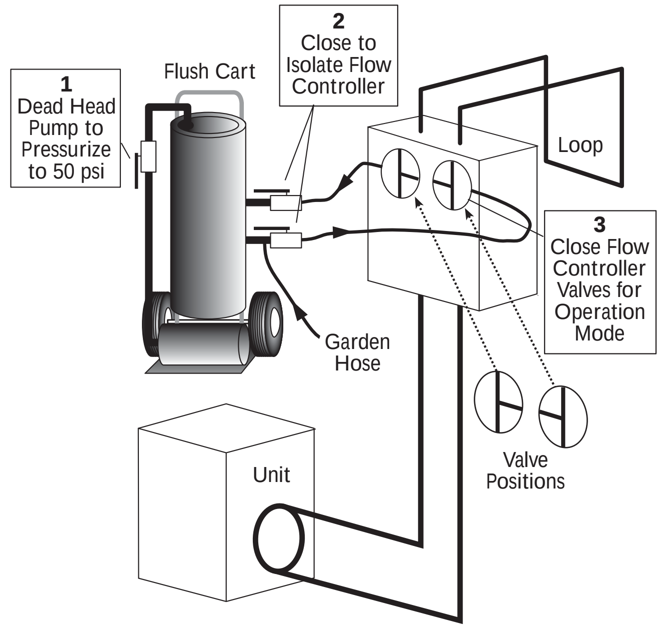




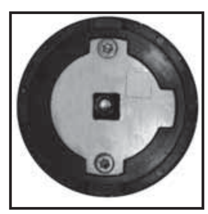
Valve Position

As shown in Figure 10E, close the flush cart return valve to pressurize the loop to at least 50 psi [345 kPa], not to exceed 75 psi [517 kPa]. After pressurizing, close the flush cart supply valve to isolate the flush cart. Move the Flow Controller valves to position E. Loop static pressure will fluctuate with the seasons and pressures will be higher in the winter months than during the cooling season. This fluctuation is normal and should be considered when charging the system initially. Unhook the flush cart from the Flow Controller. Install Flow Controller caps to ensure that any condensation/leakage remains contained within the Flow Controller package. If water pressure is too low to pressurize the loop to between 50 and 75 psi [345 to 517 kPa], use a hydraulic pump to pressure the loop through the P/T port, being careful to bleed any air before introducing any fluid through the P/T port (Some weed sprayers works well as hydraulic pumps).

Figure 10e: Valve Position E - Pressurize and Operation



Front of F.C.



Valve Position

NOTICE: It is always a good idea to plan for a service call/ check-up the first summer of operation, as the loop pressure may be low due to the stretching of the pipe/rubber hose after the pipe has settled into the ground and the warmer summer loop temperatures cause the piping to expand. This is typical of all new installations. Pressures can easily be “topped off” with the use of a garden hose and P/T adapter. Install the garden hose and adapter in the “water in” P/T fitting; install a pressure gauge in the “water out” P/T fitting. If the loop pressure is between 50 and 75 psi [345 to 517 kPa] upon completion of the service call, pressures should be sufficient for all seasons.

NOTICE: Consult the ClimaDry AOM for flushing instructions for units with ClimaDry Whole House Dehumidification.

Antifreeze Selection

General

In areas where minimum entering loop temperatures drop below 40°F [4.4°C] or where piping will be routed through areas subject to freezing, antifreeze is needed. Alcohols and glycols are commonly used as antifreeze solutions. Your local representative should be consulted for the antifreeze best suited to your area. Freeze protection should be maintained to 15°F [8.5°C] below the lowest expected entering loop temperature. For example, if 30°F [-1°C] is the minimum expected entering loop temperature, the leaving loop temperature would be approximately 22 to 25°F [-5.5 to -3.9°C] and freeze protection should be at 15°F [-9.5°C]. Calculations are as follows:
30°F - 15°F = 15°F [-1°C - 8.5°C = -9.5°C]

All alcohols should be premixed and pumped from a reservoir outside of the building when possible or introduced under water level to prevent fuming. Initially calculate the total volume of fluid in the piping system using Table 3. Then use the percentage by volume shown in Table 4 for the amount of antifreeze. Antifreeze concentration should be checked from a well mixed sample using a hydrometer to measure specific gravity.

Antifreeze Characteristics

Selection of the antifreeze solution for closed loop earth coupled systems requires the consideration of many important factors which have long-term implications on the performance and life of the equipment. Each area of concern leads to a different "best choice" of antifreeze. The fact is that there is no "ideal" antifreeze and any choice will require compromises in one area or another. Some of the factors to consider are safety, thermal performance, corrosiveness, local codes, stability, convenience, and cost.

Table 3: Fluid Volume

Fluid Volume (gal [liters] per 100' [30 meters] Pipe)		
Pipe	Size	Volume (gal) [liters]
Copper	1"	4.1 [15.3]
	1.25"	6.4 [23.8]
	2.5"	9.2 [34.3]
Rubber Hose	1"	3.9 [14.6]
Polyethylene	3/4" IPS SDR11	2.8 [10.4]
	1" iPS SDR11	4.5 [16.7]
	1.25" IPS SDR11	8.0 [29.8]
	1.5" IPS SDR11	10.9 [40.7]
	2" IPS SDR11	18.0 [67.0]
	1.25" IPS SCH40	8.3 [30.9]
	1.5" IPS SCH40	10.9 [40.7]
	2" IPS SCH40	17.0 [63.4]
Unit Heat Exchanger	Typical	1.0 [3.8]
Flush Cart Tank	10" Dia x 3ft tall [254mm x 91.4cm tall]	10 [37.9]

⚠ WARNING! ⚠

WARNING! Always dilute alcohols with water (at least 50% solution) before using. Alcohol fumes are flammable and can cause serious injury or death if not handled properly.

Chart 1a: Methanol Specific Gravity

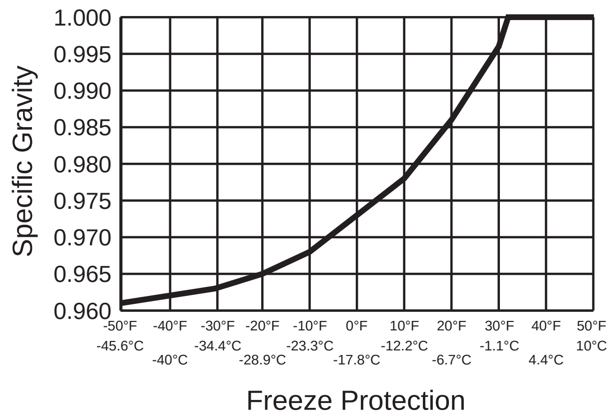


Chart 1b: Propylene Glycol Specific Gravity

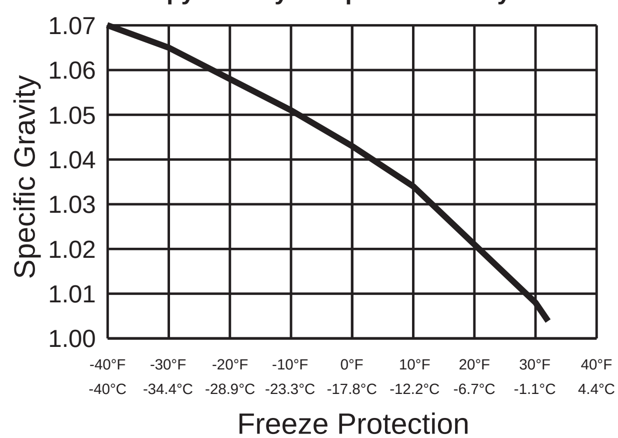
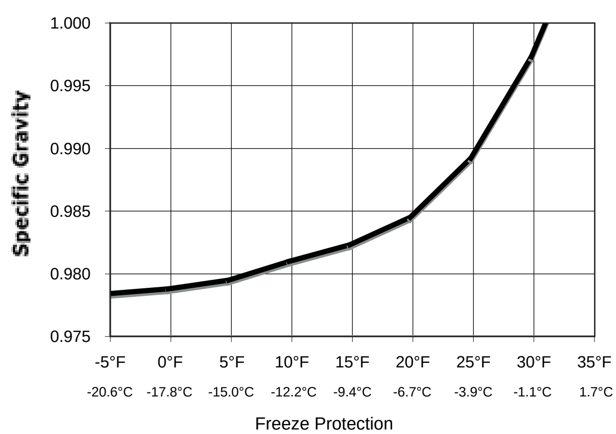


Chart 1c: Ethanol Specific Gravity



Antifreeze Selection

Table 4: Antifreeze Percentages by Volume

Type	Minimum Temperature for Low Temperature Protection			
	10°F [-12.2°C]	15°F [-9.4°C]	20°F [-6.7°C]	25°F [-3.9°C]
Methanol	25%	21%	16%	10%
100% USP food grade Propylene Glycol	38%	25%	22%	15%
Ethanol*	29%	25%	20%	14%

* Must not be denatured with any petroleum based product

Methanol - Methanol or wood alcohol is considered toxic in any form, has good heat transfer, low to mid price, flammable in concentrations greater than 25%, non-corrosive, and low viscosity. Methanol has delivered outstanding performance in earth loops for over 20 years. Its only drawbacks are toxicity and flammability. Although methanol enjoys widespread consumer use as a windshield washer fluid in even higher concentrations, some local codes may limit its use in earth loops. To increase safety, a premixed form should be used on the jobsite to increase the safety factor. Pure methanol can be purchased from any chemical supplier.

Ethanol - Ethanol or grain alcohol exhibits good heat transfer (slightly less than methanol), higher price, and is flammable in concentrations greater than 10%. Ethanol is generally non-corrosive and has medium viscosity. Ethanol in its pure form is considered nontoxic and shows promise as a geothermal heat transfer fluid. However the U.S. Bureau of Alcohol, Tobacco, and Firearms (ATF) limit its distribution. All non-beverage ethanol is required to be denatured and rendered unfit to drink. Generally this is done by adding a small percentage of toxic substances such as methanol, benzene, or gasoline as a denaturant. Many of these denaturants are difficult to identify by the casual user and many are not compatible with polyethylene pipe. Only denatured ethanol can be purchased for commercial use. The use of ethanol is not recommended because of the unknown denaturants included in the solution, and their possible toxicity and damage resulting to polyethylene piping systems. Denaturing agents that are petroleum based can damage polyethylene pipe.
Ethylene glycol - Generally non-corrosive, expensive, medium heat transfer, considered toxic. Its toxicity has prevented its widespread use in the ground source industry in spite of its widespread use in traditional water-source heat pump applications. Ethylene glycol is not currently recommended as ground-source antifreeze.

Propylene glycol - Nontoxic, non-corrosive, expensive, hard to handle when cold, poorest heat transfer, has formed “slime-type” coatings inside pipe. Poor heat transfer has required its removal in some systems. Propylene glycol is acceptable in systems anticipating loops temperatures no colder than 40°F [4.4°C]. These systems typically use antifreeze because of low ambient conditions (outside plumbing or cooling tower, etc.). When loop temperatures are below 40°F [4.4°C], the fluid becomes very difficult to pump and heat transfer characteristics suffer greatly. Only food grade propylene glycol is recommended to prevent the corrosion inhibitors (often present in other mixtures) from reacting with local water and ‘coming out’ of solution to form slime type coatings inside heat exchangers and thus hinder heat transfer. If propylene glycol must be used (e.g. code requirements), careful consideration of loop Reynolds numbers, pump selection and pressure drop must be considered.

Potassium acetate - Nontoxic, good heat transfer, high price, non-corrosive with added inhibitors, low viscosity. Due to its low surface tension, Potassium Acetate has been known to leak through mechanical fittings and certain thread sealants. A variant of the salt family, it can be extremely corrosive when exposed to air. Potassium Acetate is not recommended in ground-source applications due to the leaking and (ultimately) corrosion problems associated with it.

Contact the Technical Services Department if you have any questions as to antifreeze selection.

⚠ WARNING! ⚠

WARNING! Always use properly marked vehicles (D.O.T. placards), and clean/suitable/properly identified containers for handling flammable antifreeze mixtures. Post and advise those on the jobsite of chemical use and potential dangers of handling and storage.

NOTICE: DO NOT use automotive windshield washer fluid as antifreeze. Most washer fluid contains chemicals that will cause foaming.

⚠ CAUTION! ⚠

CAUTION! Always obtain MSDS safety sheets for all chemicals used in ground loop applications including chemicals used as antifreeze.

Antifreeze Charging

It his highly recommended to utilize premixed antifreeze fluid where possible to alleviate many installation problems and extra labor.

The following procedure is based upon pure methanol and can be implemented during the Full Flush procedure with three way valves in the Figure 10D - Valve Position D. If a premixed methanol of 15°F [-9.4°C] freeze protection is used, the system can be filled and flushed with the premix directly to prevent handling pure methanol during the installation.

1) Flush loop until all air has been purged from system and pressurize to check for leaks before adding any antifreeze.
2) Run discharge line to a drain and hook up antifreeze drum to suction side of pump (if not adding below water level through approved container). Drain flush cart reservoir down to pump suction inlet so reservoir can accept the volume of antifreeze to be added.
3) Calculate the amount of antifreeze required by first calculating the total fluid volume of the loop from Table 3. Then calculate the amount of antifreeze needed using Table 4 for the appropriate freeze protection level. Many southern applications require freeze protection because of exposed piping and Flow Controller to ambient conditions.
4) Isolate unit and prepare to flush only through loop. Start flush cart, and gradually introduce the required amount of liquid to the flush cart tank (always introduce alcohols under water or use suction of pump to draw in directly to prevent fuming) until attaining the proper antifreeze protection. The rise in flush reservoir level indicates amount of antifreeze added (some carts are marked with measurements in gallons or liters). A ten inch [25.4 cm] diameter cylinder, 3 foot [91.4 cm] tall holds approximately 8 gallons [30.3 liters] of fluid plus the hoses (approx. 2 gallons, [7.6 liters], which equals about 10 gallons [37.9 liters] total. If more than one tankful is required, the tank should be drained immediately by opening the waste valve of the flush cart noting the color of the discharge fluid. Adding food coloring to the antifreeze can help indicate where the antifreeze is in the circuit and prevents the dumping of antifreeze out the waste port. Repeat if necessary.
5) Be careful when handling methanol (or any alcohol). The fumes are flammable, and care should be taken with all flammable liquids. Open flush valves to flush through both the unit and the loop and flush until fluid is homogenous and mixed. It is recommended to run the unit in the heating and cooling mode for 15-20 minutes each to ‘temper’ the fluid temperature and prepare it for pressurization. Devoting this time to clean up can be useful. This procedure helps prevent the periodic “flat” loop condition.
6) Close the flush cart return valve; and immediately thereafter, close the flush cart supply valve, leaving a positive pressure in the loop of approximately 50 psi [345 kPa]. This is a good time to pressure check the system as well. Check the freeze protection of the fluid with the proper hydrometer to ensure that the correct amount of antifreeze has been added to the system. The hydrometer can be dropped into the flush reservoir and the reading compared to Chart 1A for Methanol, 1B for Propylene Glycol, and 1C for Ethanol to indicate the level of freeze protection. Do not antifreeze more than a +10°F [-12.2°C] freeze point. Specific gravity hydrometers are available in the residential price list. Repeat after reopening and flushing for a minute to ensure good second sample of fluid. Inadequate antifreeze protection can cause nuisance low temperature lockouts during cold weather.

⚠ WARNING! ⚠

WARNING! Always dilute alcohols with water (at least 50% solution) before using. Alcohol fumes are flammable and can cause serious injury or death if not handled properly.

7) Close the flush cart return valve; immediately thereafter, close the flush cart supply valve, shut off the flush cart leaving a positive pressure in the loop of approximately 50-75 psi [345-517 kPa]. Refer to Figure 10E for more details.

Heat Pump Low Water Temperature Cutout Selection

The CXM control allows the field selection of low water (or water-antifreeze solution) temperature limit by clipping jumper JW3 - FP1, which changes the sensing temperature associated with thermistor FP1. Note that the FP1 thermistor is located on the refrigerant line between the coaxial heat exchanger and expansion device (TXV). Therefore, FP1 is sensing refrigerant temperature, not water temperature, which is a better indication of how water flow rate/ temperature is affecting the refrigeration circuit.

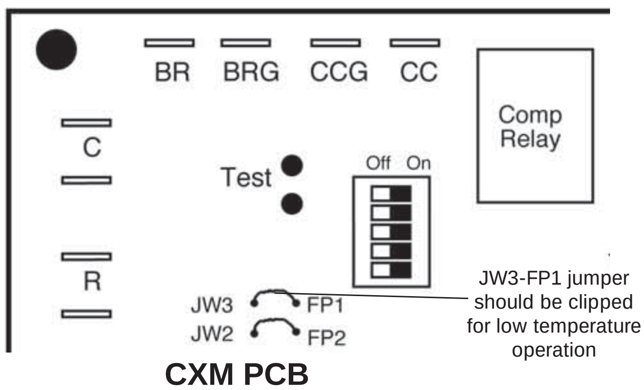
NOTICE: Always verify proper freeze protection level BEFORE changing FP1 setting.

The factory setting for FP1 is for systems using water (30°F [-1.1°C] refrigerant temperature). In low water temperature (extended range) applications with antifreeze (most ground loops), jumper JW3 - FP1 should be clipped as shown in Figure 11 to change the setting to 10°F [-12.2°C] refrigerant temperature, a more suitable temperature when using an antifreeze solution. All residential units include water/ refrigerant circuit insulation to prevent internal condensation, which is required when operating with entering water temperatures below 59°F [15°C].

NOTICE: Failure to clip jumper JW3 - FP1 will result in a service call in heating season when the unit locks out on low water temperature fault.

Antifreeze Charging

Figure 11: Low Temperature Cutout Selection



Pressure/Temperature Ports
The pressure/temperature ports (P/T ports) supplied with the earth loop connector kit are provided as a means of measuring flow and temperature. The water flow through the unit can be checked by measuring the incoming water pressure at the supply water P/T port and subtracting the leaving water pressure at the return water P/T port. Comparing the pressure differential to the pressure drop table/flow rate in the unit installation manual will determine the flow rate through the unit. Ground loop required flow rates are 2.25 to 3 U.S. gpm per nominal cooling ton [2.41 to 3.23 l/m per kW]. Note: Minimum flow for units is 2.25 gpm per ton [2.41 l/m per kW].

Example: Model 036 has a 50°F entering water temperature (EWT) and 50 psi entering water pressure (EWP). The leaving water pressure (LWP) is 46 psi. Pressure Drop (PD) = EWP - LWP = 50 - 46 = 4 psi. In the unit Installation manual, a 3.9 PSI pressure drop is equivalent to 9 GPM at 50°F EWT on the chart. More flow will not hurt the performance. However, insufficient flow can significantly reduce capacity and possibly even cause damage to the heat pump in extreme conditions. Digital thermometers and pressure gauges are needed for the P/T ports, which are available in the residential price list.

NOTICE: Pressure/temperature gauges should be pushed gently into P/T ports to prevent internal damage to the port. Use same gauge and thermometer to determine the differential in pressure and temperature

Earth Loop Pressure
The earth loop must have a slight positive pressure to operate the pumps [>3 psi, >20.7 kPa]. The system pressure will drop as the earth loop pipe relaxes, and will fluctuate as the fluid temperature changes. Typical earth loop pressures range from approximately 15-50 psi [103-345 kPa]. At the start-up of a system, the earth loops should have a (static) holding pressure of approximately 50-75 psi [345-517 kPa].

Maximum operating pressure should never exceed 100 psi [689 kPa] under any circumstance.

NOTICE: It is recommended to run the unit in the cooling, then heating mode for 15-20 minutes each to ‘temper’ the fluid temperature and prepare it for pressurization. This procedure helps prevent the periodic “flat” loop condition of no pressure.

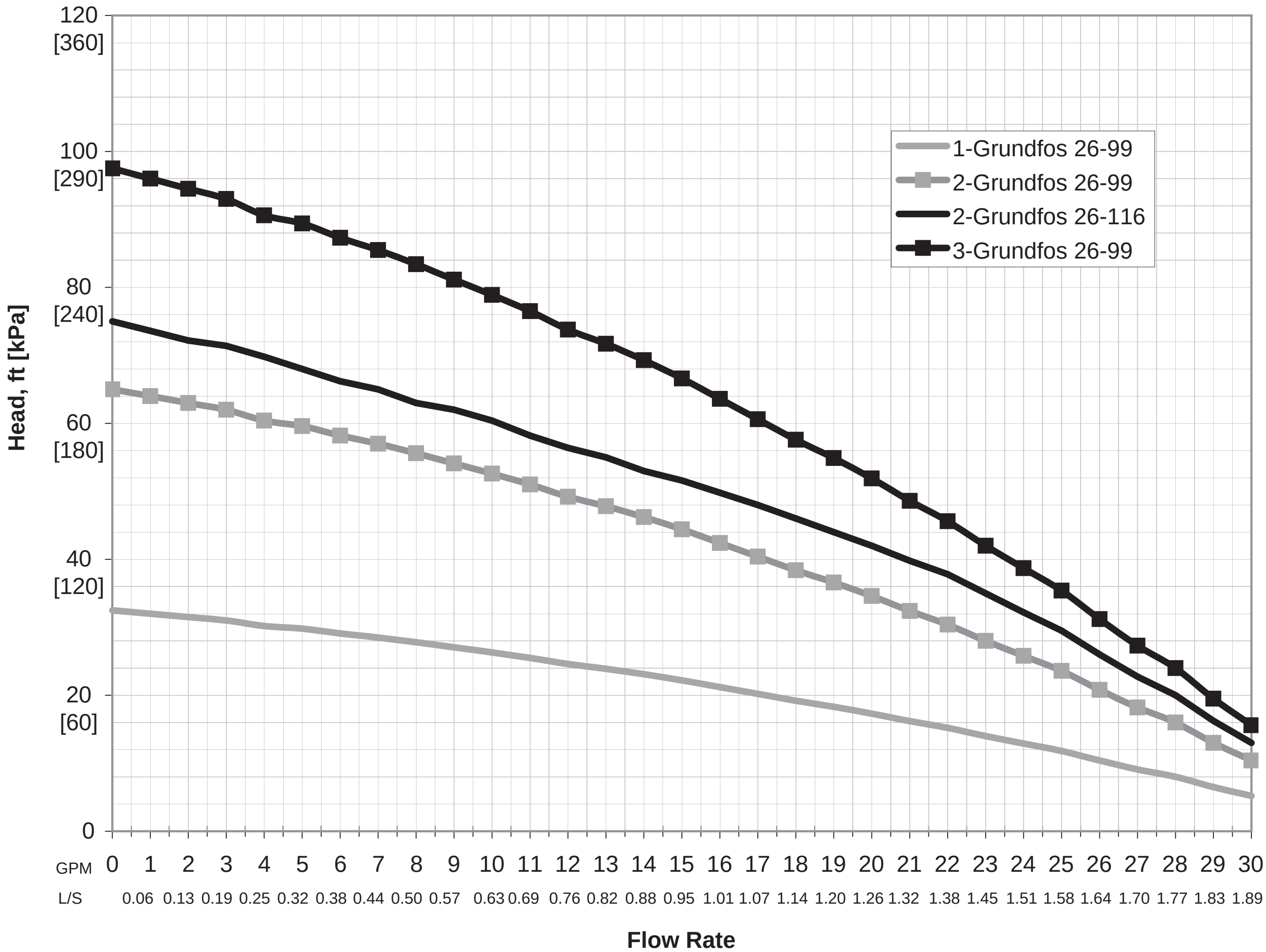
After pressurization, be sure the loop Flow Controller provides adequate flow through the unit by checking pressure drop across the heat exchanger and comparing it to the pressure drop/flow rate tables in the unit Installation manual. Flow Controller pump performance is shown in Chart 2.

Start-Up of Flow Controller
1) Check to make sure that the loop and unit isolation valves (if applicable) are completely open and the flush ports are closed and sealed.
2) Check and record the earth loop pressure via the P/T ports. Loop Pressure = In______ Out______.
3) Check and record the flow rate.
   Flow Rate = ______gpm.
4) Check performance of unit. Refer to unit installation manual. Replace all caps to prevent pressure loss.

When replacing a pump, isolate the pump from loop as in Figure 12. Always disable power to the pumps and remove pump power wiring if needed. The five steps below outline the detailed procedure.

Flow Controller Pump Curves

Chart 2: Flow Controller Performance



Pump Replacement Procedure

⚠ WARNING! ⚠

WARNING! Disconnect electrical power source to prevent injury or death from electrical shock.

1. Close valves as shown in Figure 12.
2. Place rag under pump to collect loop fluid.
3. Remove 4 Allen head mounting bolts and lift off pump stator housing.
4. Replace with new pump insuring no foreign material has been introduced, and evenly install the four Allen head mounting bolts.
5. Place garden hose supply and return on flush ports as shown in Figure 12 and open valves to flush through the unit portion of loop. When water flows clear, close return side to pressurize. Then, close the supply side valve. Finally, close 3-way valves to operation position as shown in Figure 10E. In situations where this procedure may not be feasible, the loop can also be re-flushed using the complete flushing procedure outlined for installation.

NOTICE: Remember this procedure will dilute the antifreeze mixture by a couple of gallons [7-8 liters]. If performed more than twice on any earth loop, the antifreeze concentration should be checked with a hydrometer and antifreeze added as needed.

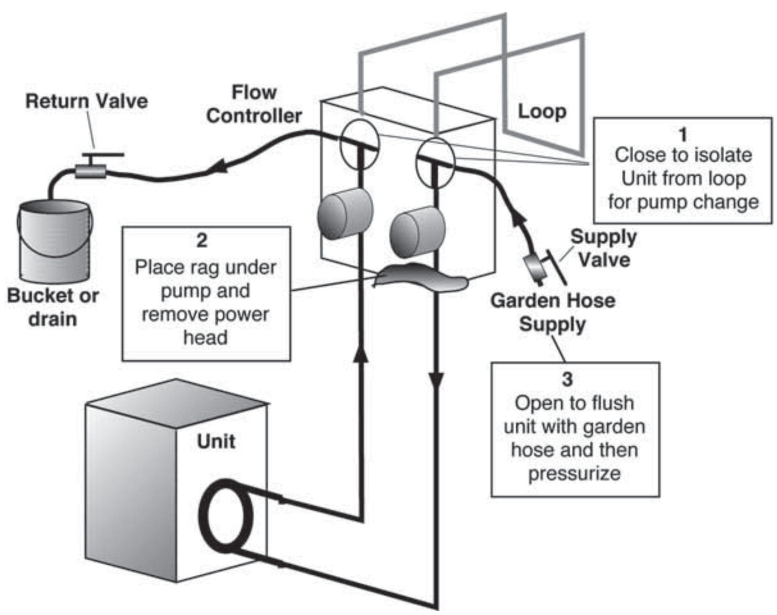
NOTICE: Before attempting to replace an existing Flow Controller pump motor, verify the model numbers with a distributor, as there have been several pump/valve/Flow Controller vendors used with this equipment. Grundfos and Taco pumps and even different revisions of the same brand of pump are not compatible with each other.

Closed Loop Basics

Closed Loop Earth Coupled Heat Pump systems are commonly installed in one of three configurations: horizontal, vertical and pond loop. Each configuration provides the benefit of using the moderate temperatures of the earth as a heat source/heat sink. Piping configurations can be either series or parallel.

Series piping configurations typically use 1-1/4 inch, 1-1/2 inch or 2 inch pipe. Parallel piping configurations typically

Figure 12: Pump Replacement Procedure



Front of F.C.

Valve Position

use 3/4 inch or 1 inch pipe for loops and 1-1/4 inch, 1-1/2 inch or 2 inch pipe for headers and service lines. Parallel configurations require headers to be either “closed-coupled” short headers or reverse return design.

Select the installation configuration which provides you and your customer the most cost effective method of installation after considering all application constraints.

Loop design takes into account two basic factors. The first is an accurately engineered system to function properly with low pumping requirements (low Watts) and adequate heat transfer to handle the load of the structure. The second is to design a loop with the lowest installed cost while still maintaining a high level of quality. These factors have been taken into account in all of the loop designs presented in this manual.

In general terms, all loop lengths have been sized by the GeoDesigner loop sizing software so that every loop has approximately the same operating costs. In other words, at the end of the year the homeowner would have paid approximately the same amount of money for heating, cooling, and hot water no matter which loop type was installed. This leaves the installed cost of the loop as the main factor for determining the system payback. Therefore, the “best” loop is the most economical system possible given the installation requirements.

Pipe Fusion Methods
Two basic types of pipe joining methods are available for earth coupled applications. Polyethylene pipe can be socket fused or butt fused. In both processes the pipe is actually melted together to form a joint that is even stronger than the original pipe. Although when either procedure is performed properly the joint will be stronger than the pipe wall, socket fusion in the joining of 2” pipe or less is preferred because of the following:

- Allowable tolerance of mating the pipe is much greater in socket fusion. According to general fusion guidelines, a 3/4” SDR11 butt fusion joint alignment can be off no more than 10% of the wall thickness (0.01 in. [2.54mm]). One hundredth of an inch (2-1/2 mm) accuracy while fusing in a difficult position can be almost impossible to attain in the field.
- The actual socket fusion joint is 3 to 4 times the cross sectional area of its butt fusion counterpart in sizes under 2” and therefore tends to be more forgiving of operator skill.
- Joints are frequently required in difficult trench connections and the smaller socket fusion iron is more mobile. Operators will have less of a tendency to cut corners during the fusion procedure, which may happen during the facing and alignment procedure of butt fusion.

In general socket fusion loses these advantages in fusion joints larger than 2” and of course socket fittings become very expensive and time consuming in these larger sizes. Therefore, butt fusion is generally used in sizes larger than 2”. In either joining method proper technique is essential for long lasting joints. All pipe and fittings in the residential price list are IGSHPA (International Ground Source Heat Pump Association) approved. All fusion joints must be performed by certified fusion technicians. Table 5 illustrates the proper fusion times for Geothermal PE 3408 ASTM Pipe.

Table 5: Fusion Times for Polyethylene 3408 ASTM Pipe

Pipe Size	Socket Fusion Time (Sec)	Butt Fusion		Holding Time	Curing Time
		Time (sec.)	Bead, in [mm]		
3/4” IPS	8 - 10	8	1/16 [1.6]	60 Sec	20 min
1” IPS	10 - 14	12	1/16 [1.6]	60 Sec	20 min
1-1/4” IPS	12 - 15	15	1/16 - 1/8 [1.6 - 3.2]	60 Sec	20 min
1-1/2” IPS	15 - 18	15	1/16 - 1/8 [1.6 - 3.2]	60 Sec	20 min
2” IPS	18 - 22	18	1/8 [3.2]	60 Sec	20 min

Always use a timing device

Parallel vs Series Configurations
Initially, loops were all designed using series style flow due to the lack of fusion fittings needed in parallel systems. This resulted in large diameter pipe (>1-1/4”) being used to reduce pumping requirements due to the increased pressure drop of the pipe. Since fusion fittings have become available, parallel flow using (3/4” IPS) for loops 2 ton [7 kW] and above has become the standard for a number of reasons.

- Cost of Pipe - The larger diameter (>1-1/4”) pipe is twice the cost of the smaller (3/4” IPS) pipe. However, the heat transfer capability due to the reduced surface area of the smaller pipe is only decreased by approximately 10-20%. In loop designs using the smaller pipe, the pipe length is simply increased to compensate for the small heat transfer reduction, although it still results in around 50% savings in pipe costs over the larger pipe in series. In some areas 1-1/4” vertical bores can be more cost effective, where drilling costs are high.
- Pumping power - Parallel systems generally can have much lower pressure drop and thus smaller pumps due to the multiple flow paths of smaller pipes in parallel.
- Installation ease - The smaller pipe is easier to handle during installation than the larger diameter pipe. The ‘memory’ of the pipe can be especially cumbersome when installing in cold conditions. Smaller pipe takes less time to fuse and is easier to cut, bend, etc.

Geothermal Closed Loop Design

In smaller loops of two tons [7 kW] or less, the reasons for using parallel loops as listed above may be less obvious. In these cases, series loops can have some additional advantages:

- No header - fittings tend to be more expensive and require extra labor and skill to install.
- Simple design - no confusing piping arrangement for easier installation by less experienced installers.

Parallel Loop Design
Loop Configuration - Determining the style of loop primarily depends on lot (yard) size and excavation costs. For instance, a horizontal 1 pipe loop will have significantly (400%) more trench than a horizontal 6 pipe loop. However, the 6 pipe will have about 75% more feet of pipe. Therefore, if trenching costs are higher than the extra pipe costs, the 6 pipe loop is the best choice. Remember that labor is also a factor in loop costs. The 6 pipe loop could also be chosen because of the small available space. Generally a contractor will know after a few installations which configuration is the most cost effective. This information can be applied to later installations for a more overall cost effective installation for the particular area. Depth of the loop in horizontal systems generally does not exceed 5 feet [1.5 meters] because of trench safety issues and the sheer amount of soil required to move. In vertical systems economic depth due to escalating drilling costs in rock can sometimes require what is referred to as a parallel-series loop. That is, a circuit will loop down and up through two consecutive bores (series) to total the required circuit length. Moisture content and soil types also effect the earth loop heat exchanger design. Damp or saturated soil types will result in shorter loop circuits than dry soil or sand.

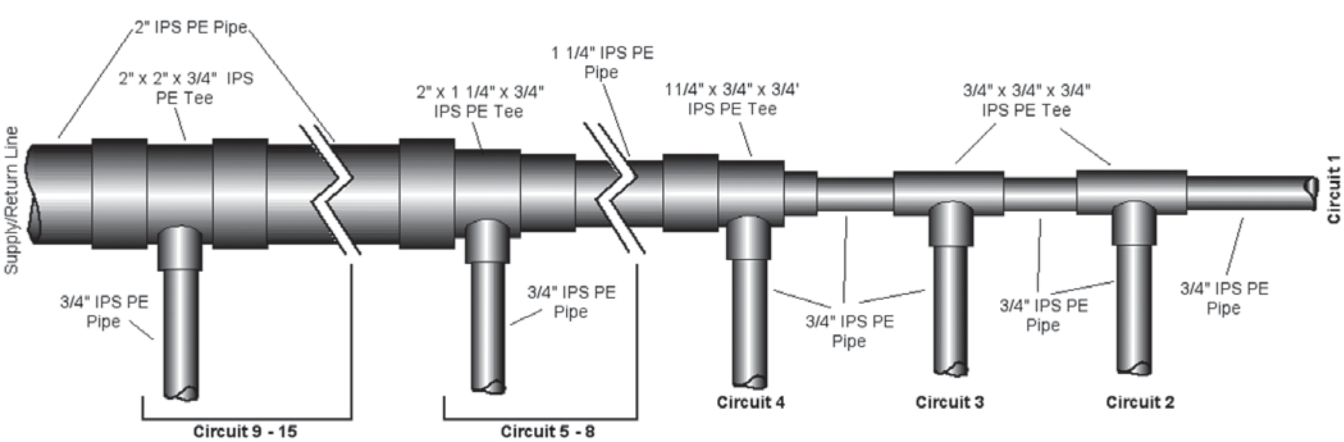
Loop Circuiting - Loops should be designed with a compromise between pressure drop and turbulent flow (Reynold’s Number) in the heat exchange pipe for heat transfer. Therefore the following rules should be observed when designing a loop:

- 3 gpm per ton [3.23 l/m per kW] flow rate (2.25 gpm per ton [2.41 l/m per kW] minimum). In larger systems 2.5 to 2.7 gpm per ton [2.41 to 2.90 l/m per kW] is adequate in most cases. Selecting pumps to attain exactly 3 gpm per ton [3.23 l/m per kW] is generally not cost effective from an operating cost standpoint.
- One circuit per nominal equipment ton [3.5 kW] with 3/4” IPS and 1” IPS circuit per ton [3.5 kW]. This rule can be deviated by one circuit or so for different loop configurations.

Header Design - Headers for parallel loops should be designed with two factors in mind, the first is pressure drop, and the second is ability to purge all of the air from the system (“flushability”). The header shown in Figure 13A is a standard header design through 15 tons [52.8 kW] for polyethylene pipe with 2” supply and return runouts. The header shown in Figure 13B is a standard header design through 5 tons [17.6 kW] for polyethylene pipe using 1-1/4” supply and return runouts. Notice the reduction of pipe from 2” IPS supply/return circuits 15 to 8 to 1-1/4” IPS pipe for circuits 7 to 4 to 3/4” IPS to supply circuits 3, 2, and 1. This allows minimum pressure drop while still maintaining 2 fps [0.6 m/s] velocity throughout the header under normal flow conditions (3 gpm/ton [3.23 l/m per kW]), thus the header as shown is self-flushing under normal flow conditions. This leaves the circuits themselves (3/4” IPS) as the only section of the loop not attaining 2 fps [0.6 m/s] flush velocity under normal flow conditions (3 gpm per ton [3.23 l/m per kW], normally 3 gpm [11.4 l/m] per circuit). Pipe diameter 3/4” IPS requires 3.8 gpm [14.4 l/m] to attain 2 fps [0.6 m/s] velocity. Therefore, to calculate flushing requirements for any PE loop using the header styles shown, simply multiply the number of circuits by the flushing flow rate of each circuit (3.8 gpm for 2 fps velocity [14.4 l/m for 0.6 m/s]). For instance, on a 5 circuit loop, the flush flow rate is 5 circuits x 3.8 gpm/circuit = 19 gpm [5 circuits x 14.4 l/m per circuit = 72 l/m or 1.2 l/s].

NOTICE: Whenever designing an earth loop heat exchanger, always assume the worst case, soil and moisture conditions at the job site in the final design. In other words, if part of the loop field is saturated clay, and the remainder is damp clay, assume damp clay for design criteria.

Headers that utilize large diameter pipe feeding the last circuits should not be used. PE 1-1/4” IPS pipe requires 9.5

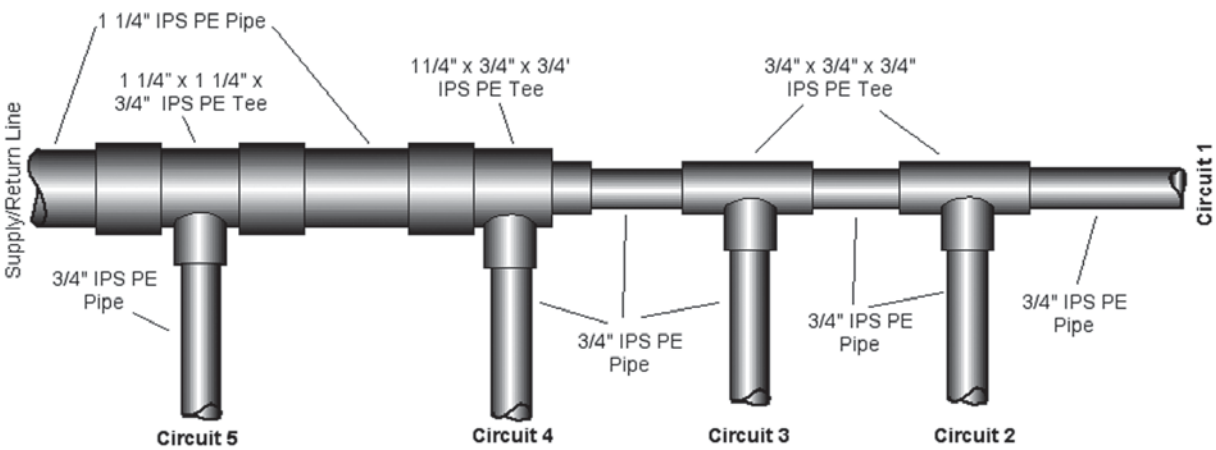


Geothermal Closed Loop Design

gpm [36 l/m] to attain 2 fps [0.6 m/s] and since increasing the flow through the last circuit would also require increasing the flow through the other circuits at an equal rate as well, we can estimate the flush flow requirements by multiplying the number of circuits by 9.5 gpm [36 l/m] for 1-1/4" IPS. For instance, a 5 circuit loop would require 5 circuits x 9.5 gpm/circuit = 47.5 gpm [5 circuits x 36 l/m per circuit = 180 l/m or 3.0 l/s] to attain flush flow rate. This is clearly is a difficult flow to achieve with a pump of any size.

Header Layout - Generally header layouts are more cost effective with short headers. This requires centrally locating the header to all circuits and then bringing the circuits to the header. One of the easiest implementations is to angle all trenches into a common pit similar to a starburst. This layout can utilize the laydown or 'L' header and achieves reverse return flow by simply laying the headers down in a mirror image and thus no extra piping or labor. Figure 14 details a "laydown" header.

Figure 13b: Typical Header Through 5 Tons

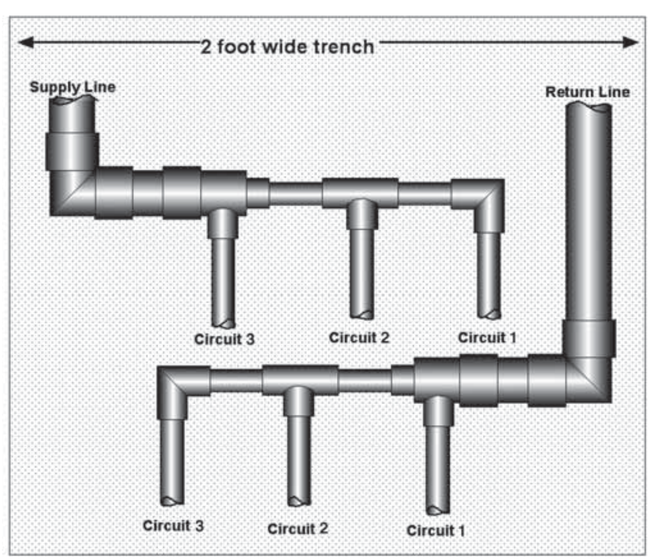


Inside Piping - Polyethylene pipe provides an excellent no leak piping material inside the building. Inside piping fittings and elbows should be limited to prevent excessive pressure drop. Hose kits employing 1" rubber hose should be limited in length to 10-15 feet [3 to 4.5 meters] per run to reduce pressure drop problems. In general 2 feet of head [6 kPa] pressure drop is allowed for all earth loop fittings which would include 10-12 elbows for inside piping to the Flow Controller. This allows a generous amount of maneuvering to the Flow Controller with the inside piping. Closed cell insulation (3/8" to 1/2" [9.5 to 12.7 mm] wall thickness) should be used on all inside piping where loop temperatures below 50°F [10°C] are anticipated. All barbed connections should be double clamped.

Flow Controller Selection - The pressure drop of the entire ground loop should be calculated for the selection of the Flow Controller (a pressure drop spreadsheet is downloadable from the web site). In general, if basic loop design rules are followed, units of 3 tons [10.6 kW] or less will require only 1 circulating pump (UP26-99). Units from 3.5 to 6 tons [12.3 to 21.1 kW] will require a two pump system (2 - UP26-99). Larger capacity units with propylene glycol as antifreeze may require 2 - UP26-116 pumps. However, the UP26-116 should be avoided where possible, as power consumption of the 26-116 is significantly higher than the 26-99, which will affect heating and cooling operating costs. In many cases, where pressure drop calcuations may call for 3 - UP26-99 pumps, try substituting 2 - UP26-116 pumps. This makes the installation much easier and reduces cost. Chart 2 shows the various pump combinations.

Loop pressure drop calculation should be performed for accurate flow estimation in any system including unit, hose kit, inside piping, supply/return headers, circuit piping, and fittings. Use Tables 6A through 6E for pressure drop calculations using antifreeze and PE/rubber hose piping materials.

Figure 14: Typical "Laydown" Header



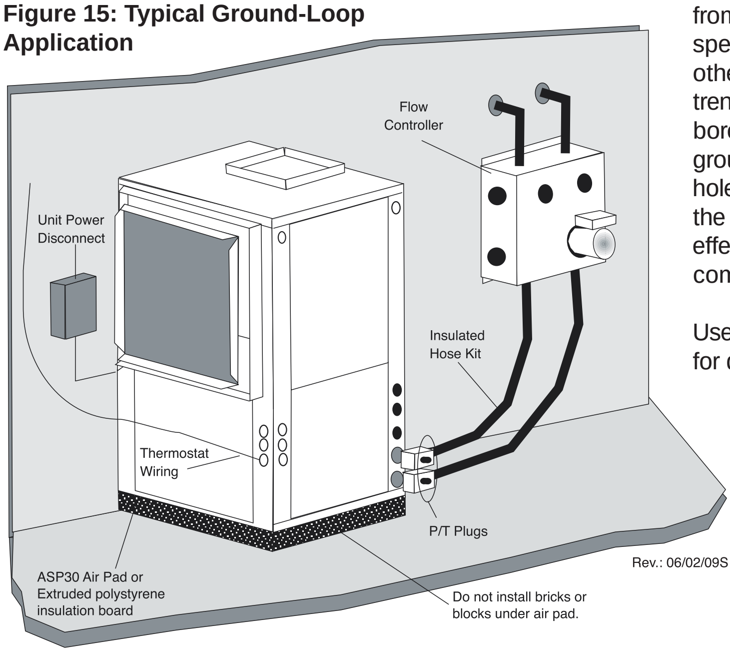
Geothermal Closed Loop Design

Prior to installation, locate and mark all existing underground utilities, piping, etc. Install loops for new construction before sidewalks, patios, driveways and other construction has begun. During construction, accurately mark all ground loop piping on the plot plan as an aid in avoiding potential future damage to the installation (see Site Survey Sheet). This should be done before and after loop installation. Final installation should be plotted from two fixed points to triangulate the header/manifold location.

Loop Piping Installation
The typical closed loop ground source system is shown in Figure 15. All earth loop piping materials should be limited to only polyethylene fusion in below ground (buried) sections of the loop. Galvanized or steel fittings should not be used at any time due to the tendency to corrode by galvanic action. All plastic to metal threaded fittings should be avoided as well due to the potential to leak in earth coupled applications; a flanged fitting should be substituted. P/T plugs should be used so that flow can be measured using the pressure drop of the unit heat exchanger in lieu of other flow measurement means (e.g. flow meter, which adds additional fittings and potential leaks). Earth loop temperatures can range between 25-110°F [-4 to 43°C]. Flow rates of 2.25 to 3 gpm per ton [2.41 to 3.23 l/m per kW] of cooling capacity are recommended for all earth loop applications.

Horizontal Applications
For horizontal earth loops, dig trenches using either a chain-type trenching machine or a backhoe. Dig trenches approximately 8-10 feet [2.5 to 3 meters] apart (edge to edge of next trench). Trenches must be at least 10 feet [3 meters] from existing utility lines, foundations and property lines and at least 50 feet [15.2 meters] minimum from privies and wells. Local codes and ordinances supersede any recommendations in this manual. Trenches may be curved to avoid obstructions and may be turned around corners. When multiple pipes are laid in a trench, space pipes properly and backfill carefully to avoid disturbing the spacing between the pipes in the trench. Figure 16 details common loop cross-sections used in horizontal loops. Actual number of circuits used in each trench will vary depending upon property size. Use GeoDesigner software to determine the best layout.

Figure 15: Typical Ground-Loop Application



Vertical Applications
For vertical earth loops, drill boreholes using any size drilling equipment. Regulations which govern water well installations also apply to vertical ground loop installations. Vertical applications typically require multiple boreholes. Space boreholes a minimum of 10 feet [3 meters] apart. In southern or cooling dominated climates 15 feet is required. Commercial installations may require more distance between bores. This manual is not intended for commercial loop design.

The minimum diameter bore hole for 3/4 inch or 1 inch U-bend well bores is 4 inches [102 mm]. Larger diameter boreholes may be drilled if convenient. Assemble each U-bend assembly, fill with water and perform a hydrostatic pressure test prior to insertion into the borehole.

To add weight and prevent the pipe from curving and digging into the borehole wall during insertion, tape a length of conduit, pipe or reinforcing bar to the U-bend end of the assembly. This technique is particularly useful when inserting the assembly into a borehole filled with water or drilling mud solutions, since water filled pipe is buoyant under these circumstances.

Carefully backfill the boreholes with an IGSHPA approved Bentonite grout (typically 20% silica sand soilds by weight) from the bottom of the borehole to the surface. Follow IGSPHA specifications for backfilling unless local codes mandate otherwise. When all U-bends are installed, dig the header trench 4 to 6 feet [1.2 to 1.8 meters] deep and as close to the boreholes as possible. Use a spade to break through from ground level to the bottom of the trench. At the top of the hole, dig a relief to allow the pipe to bend for proper access to the header. The “laydown” header mentioned earlier is a cost effective method for connecting the bores. Figure 17 illustrates common vertical bore heat exchangers.

Use an IGSHPA design based software such as GeoDesigner for determining loop sizing and configurations.

Pond/Lake Applications
Pond loops are one of the most cost effective applications of geothermal systems. Typically 1 coil of 300 ft of PE pipe per ton [26 meters per kW -- one 92 meter coil per 3.5 kW of capacity] is sunk in a pond and headered back to the structure. Minimum pond sizing is 1/2 acre [0.2 hectares] and minimum 8 to 10 feet [2.4 to 3 meters] deep for an average residential

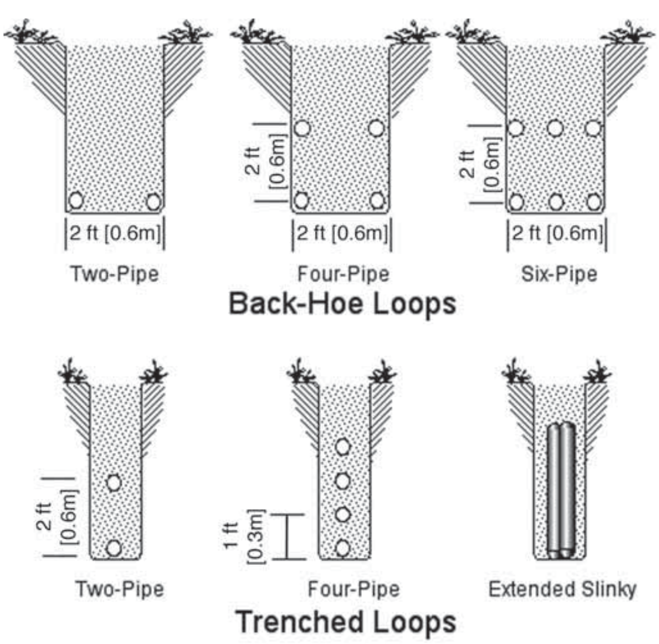
Closed Loop Installation

⚠ CAUTION! ⚠

CAUTION! This manual is not intended for commercial loop design.

home. Actual area can be 1500-3000 sq. ft. per ton [39.6 to 79.2 sq. meters per kW] of cooling. In the north, an ice cover is required during the heating season to allow the pond to reach an average 39°F [3.9°C] just below the ice cap. Winter aeration or excessive wave action can lower the pond temperature preventing ice caps from forming and freezing, adversely affecting operation of the geothermal loop. Direct use of pond, lake, or river water is discouraged because of the potential problems of heat exchanger fouling and pump suction lift. Heat exchanger may be constructed of either multiple 300 ft. [92 meter] coils of pipe or slinky style loops as shown in Figure 18. In northern applications the slinky or matt style is recommended due to its superior performance in heating. Due to pipe and antifreeze buoyancy, pond heat exchangers will need weight added to the piping to prevent floating. 300 foot [92 meter] coils require two 4” x 8” x 16” [102 x 203 x 406 mm] blocks (19 lbs. [8.6 kg] each) or 8-10 bricks (4.5 lbs [2.1 kg] each) and every 20 ft [6 meters] of 1-1/4” supply/return piping requires 1 three-hole block. Pond Coils should be supported off of the bottom by the concrete blocks. The supply/return trenching should begin at the structure and work toward the pond. Near the pond the trench should be halted and back filled most of the way. A new trench should be started from the pond back toward the partially backfilled first trench to prevent pond from flooding back to the structure.

Figure 16: Typical Horizontal Loop Configurations



Seal and protect the entry point of all earth coupling entry points into the building using conduit sleeves hydraulic cement.

Slab on Grade Construction
New Construction: When possible, position the pipe in the proper location prior to pouring the slab. To prevent wear as the pipe expands and contracts protect the pipe as shown in Figure 19. When the slab is poured prior to installation, create a chase through the slab for the service lines with 4 inch [102 mm] PVC street elbows and sleeves.

Retrofit Construction: Trench as close as possible to the footing. Bring the loop pipe up along the outside wall of the footing until it is higher than the slab. Enter the building as close to the slab as the construction allows. Shield and insulate the pipe to protect it from damage and the elements as shown in Figure 20.

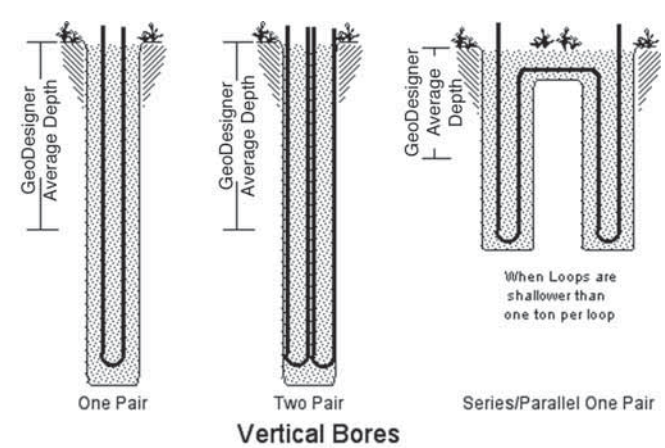
Pier and Beam (Crawl Space)
New and Retrofit Construction: Bury the pipe beneath the footing and between piers to the point that it is directly below the point of entry into the building. Bring the pipe up into the building. Shield and insulate piping as shown in Figure 21 to protect it from damage.

Below Grade Entry
New and Retrofit Construction: Bring the pipe through the wall as shown in Figure 22. For applications in which loop temperature may fall below freezing, insulate pipes at least 4 feet [1.2 meters] into the trench to prevent ice forming near the wall.

Pressure Testing
Upon completion of the ground loop piping, hydrostatic pressure test the loop to assure a leak free system.

Horizontal Systems: Test individual loops as installed. Test entire system when all loops are assembled before backfilling and pipe burial.

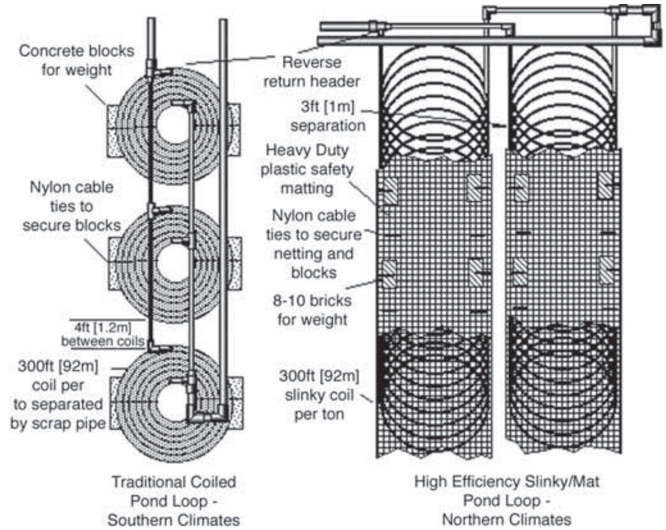
Figure 17: Typical Vertical Loop Configurations



Closed Loop Installation

Vertical U-Bends and Pond Loop Systems: Test Vertical U-bends and pond loop assemblies prior to installation with a test pressure of at least 100 psi [689 kPa]. Perform a hydrostatic pressure test on the entire system when all loops are assembled before backfilling and pipe burial.

Figure 18: Typical Pond/Lake Loop Configurations



Building Entry

Figure 19: Slab on Grade Entry Detail

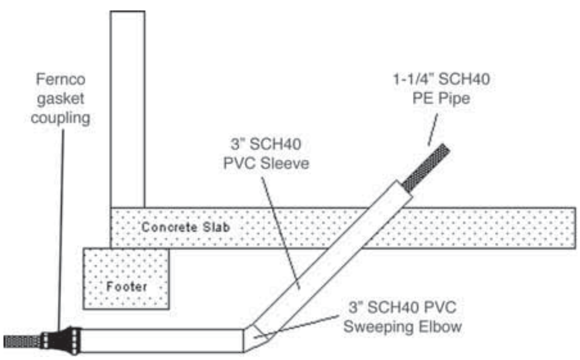


Figure 20: Retrofit Construction Detail

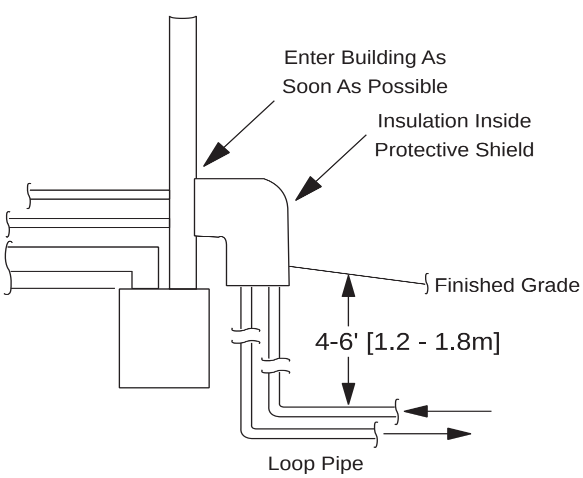


Figure 21: Pier and Beam (Craw Space) Detail

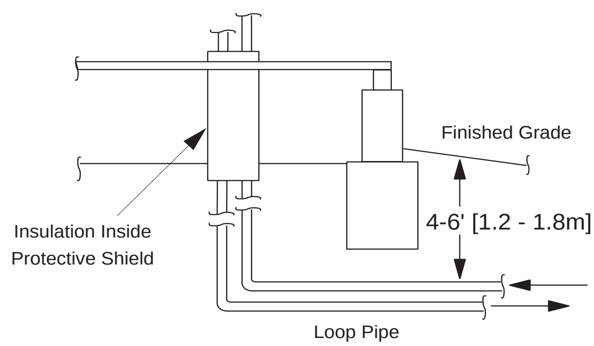
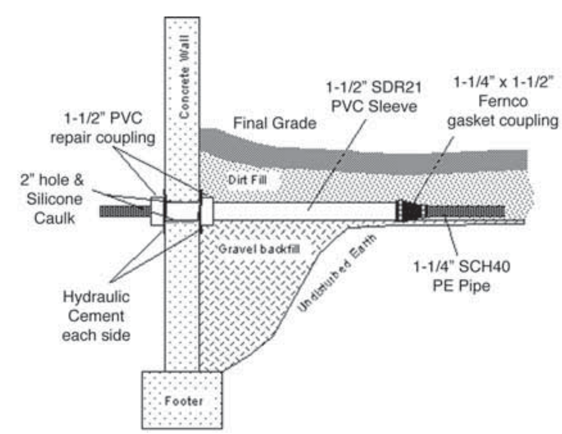


Figure 22: Below Grade Entry Detail



Pressure Drop

Table 6a: Polyethylene Pressure Drop per 100ft of Pipe
Antifreeze (30°F [-1°C] EWT): 20% Methanol by volume solution - freeze protected to 15°F [-9.4°F]

Flow Rate	3/4" IPS SDR11			1" IPS SDR11			1-1/4" IPS SCH40			1-1/2" IPS SCH40			2" IPS SCH40		
	PD (ft)	Vel (ft/s)	Re	(ft)	Vel (ft/s)	Re	PD (ft)	Vel (ft/s)	Re	PD	Vel (ft/s)	Re	PD	Vel (ft/s)	Re
1	0.36	0.55	1123	0.12	0.35	895	0.04	0.21	688	0.02	0.16	611	0.01	0.10	491
2	1.22	1.10	2245	0.42	0.70	1789	0.13	0.43	1408	0.06	0.32	1223	0.02	0.19	932
3	2.48	1.66	3388	0.85	1.06	2709	0.26	0.64	2096	0.13	0.47	1796	0.04	0.29	1423
4	4.11	2.21	4511	1.41	1.41	3604	0.43	0.86	2817	0.21	0.63	2407	0.06	0.38	1864
5	6.08	2.76	5633	2.09	1.76	4499	0.64	1.07	3504	0.31	0.79	3019	0.09	0.48	2355
6	8.36	3.31	6756	2.87	2.11	5393	0.88	1.29	4225	0.42	0.95	3630	0.13	0.57	2796
7	10.95	3.87	7899	3.76	2.47	6314	1.16	1.50	4913	0.56	1.10	4203	0.17	0.67	3287
8	13.83	4.42	9022	4.75	2.82	7208	1.46	1.72	5633	0.70	1.26	4815	0.22	0.76	3728
9	17.00	4.97	10144	5.84	3.17	8103	1.80	1.93	6321	0.86	1.42	5426	0.26	0.86	4219
10	20.44	5.52	11267	7.02	3.52	8997	2.16	2.15	7042	1.04	1.58	6037	0.32	0.96	4709
11	24.14	6.08	12410	8.29	3.87	9892	2.55	2.36	7729	1.23	1.73	6610	0.37	1.05	5151
12	28.12	6.63	13532	9.65	4.23	10812	2.98	2.57	8417	1.43	1.89	7222	0.44	1.15	5642
13	32.35	7.18	14655	11.11	4.58	11707	3.42	2.79	9138	1.65	2.05	7833	0.50	1.24	6083
14				12.65	4.93	12602	3.90	3.00	9826	1.87	2.21	8445	0.57	1.34	6574
15				14.27	5.28	13496	4.39	3.22	10546	2.11	2.36	9018	0.65	1.43	7015
16				15.97	5.64	14416	4.92	3.43	11234	2.37	2.52	9629	0.72	1.53	7506
17				17.76	5.99	15311	5.47	3.65	11955	2.63	2.68	10240	0.80	1.63	7996
18				19.63	6.34	16206	6.05	3.86	12642	2.91	2.84	10852	0.89	1.72	8438
19				21.58	6.69	17100	6.65	4.08	13363	3.20	2.99	11425	0.98	1.82	8928
20				23.61	7.04	17995	7.27	4.29	14051	3.50	3.15	12036	1.07	1.91	9370
21				25.71	7.40	18915	7.92	4.50	14738	3.81	3.31	12648	1.16	2.01	9860
22				27.89	7.75	19810	8.59	4.72	15459	4.13	3.47	13259	1.26	2.10	10302
23				30.15	8.10	20704	9.29	4.93	16147	4.47	3.62	13832	1.36	2.20	10793
24							10.00	5.15	16867	4.81	3.78	14444	1.47	2.29	11234
25							10.75	5.36	17555	5.17	3.94	15055	1.58	2.39	11725
26							11.51	5.58	18276	5.53	4.10	15666	1.69	2.49	12215
28							13.10	6.01	19684	6.30	4.41	16851	1.92	2.68	13147
30							14.78	6.44	21092	7.11	4.73	18074	2.17	2.87	14079
32							16.56	6.86	22468	7.96	5.04	19258	2.43	3.06	15011
34							18.41	7.29	23876	8.85	5.36	20481	2.70	3.25	15944
36							20.34	7.72	25285	9.78	5.67	21666	2.99	3.44	16876
38							22.36	8.15	26693	10.75	5.99	22888	3.28	3.63	17808
40							24.46	8.58	28101	11.76	6.30	24073	3.59	3.82	18740
42							26.64	9.01	29510	12.81	6.62	25296	3.91	4.02	19721
44							28.90	9.44	30918	13.90	6.93	26480	4.24	4.21	20653
46							31.24	9.87	32326	15.02	7.25	27703	4.58	4.40	21585
48										16.18	7.57	28926	4.94	4.59	22517
50										17.38	7.88	30110	5.30	4.78	23449

Pressure Drop

Table 6b: Polyethylene Pressure Drop per 100ft of Pipe
Antifreeze (30°F [-1°C] EWT): 25% Propylene Glycol by volume solution - freeze protected to 15°F [-9.4°F]

Flow Rate	3/4” IPS SDR11			1” IPS SDR11			1-1/4” IPS SCH40			1-1/2” IPS SCH40			2” IPS SCH40		
	PD (ft)	Vel (ft/s)	Re	(ft)	Vel (ft/s)	Re	PD (ft)	Vel (ft/s)	Re	PD	Vel (ft/s)	Re	PD	Vel (ft/s)	Re
1	0.42	0.55	636	0.14	0.35	507	0.04	0.21	389	0.02	0.16	346	0.01	0.10	278
2	1.41	1.10	1271	0.48	0.70	1013	0.15	0.43	798	0.07	0.32	692	0.02	0.19	528
3	2.86	1.66	1919	0.98	1.06	1534	0.30	0.64	1187	0.15	0.47	1017	0.04	0.29	806
4	4.74	2.21	2554	1.63	1.41	2041	0.50	0.86	1595	0.24	0.63	1363	0.07	0.38	1056
5	7.01	2.76	3190	2.41	1.76	2548	0.74	1.07	1985	0.36	0.79	1709	0.11	0.48	1333
6	9.64	3.31	3826	3.31	2.11	3054	1.02	1.29	2393	0.49	0.95	2056	0.15	0.57	1583
7	12.62	3.87	4473	4.33	2.47	3575	1.34	1.50	2782	0.64	1.10	2380	0.20	0.67	1861
8	15.94	4.42	5109	5.47	2.82	4082	1.69	1.72	3190	0.81	1.26	2726	0.25	0.76	2111
9	19.59	4.97	5745	6.73	3.17	4589	2.07	1.93	3580	1.00	1.42	3073	0.30	0.86	2389
10	23.56	5.52	6380	8.09	3.52	5095	2.49	2.15	3988	1.20	1.58	3419	0.37	0.96	2667
11	27.83	6.08	7028	9.56	3.87	5602	2.94	2.36	4377	1.42	1.73	3743	0.43	1.05	2917
12	32.41	6.63	7663	11.13	4.23	6123	3.43	2.57	4767	1.65	1.89	4090	0.50	1.15	3195
13				12.80	4.58	6630	3.94	2.79	5175	1.90	2.05	4436	0.58	1.24	3445
14				14.58	4.93	7136	4.49	3.00	5564	2.16	2.21	4782	0.66	1.34	3723
15				16.45	5.28	7643	5.07	3.22	5972	2.44	2.36	5107	0.74	1.43	3973
16				18.41	5.64	8164	5.67	3.43	6362	2.73	2.52	5453	0.83	1.53	4250
17				20.48	5.99	8670	6.31	3.65	6770	3.03	2.68	5799	0.92	1.63	4528
18				22.63	6.34	9177	6.97	3.86	7159	3.35	2.84	6145	1.02	1.72	4778
19				24.88	6.69	9684	7.66	4.08	7567	3.69	2.99	6470	1.12	1.82	5056
20				27.22	7.04	10190	8.38	4.29	7957	4.03	3.15	6816	1.23	1.91	5306
21				29.64	7.40	10711	9.13	4.50	8346	4.39	3.31	7162	1.34	2.01	5584
22				32.15	7.75	11218	9.90	4.72	8754	4.76	3.47	7509	1.45	2.10	5834
23							10.71	4.93	9144	5.15	3.62	7833	1.57	2.20	6112
24							11.53	5.15	9552	5.55	3.78	8179	1.69	2.29	6362
25							12.39	5.36	9941	5.96	3.94	8526	1.82	2.39	6640
26							13.27	5.58	10349	6.38	4.10	8872	1.95	2.49	6917
28							15.10	6.01	11147	7.26	4.41	9543	2.22	2.68	7445
30							17.04	6.44	11944	8.19	4.73	10235	2.50	2.87	7973
32							19.08	6.86	12723	9.18	5.04	10906	2.80	3.06	8501
34							21.22	7.29	13521	10.20	5.36	11598	3.11	3.25	9029
36							23.45	7.72	14318	11.28	5.67	12269	3.44	3.44	9557
38							25.78	8.15	15116	12.39	5.99	12961	3.78	3.63	10084
40							28.20	8.58	15914	13.56	6.30	13632	4.14	3.82	10612
42							30.71	9.01	16711	14.77	6.62	14325	4.51	4.02	11168
44										16.02	6.93	14995	4.89	4.21	11696
46										17.31	7.25	15688	5.28	4.40	12223
48										18.65	7.57	16380	5.69	4.59	12751
50										20.04	7.88	17051	6.11	4.78	13279

Pressure Drop

Table 6c: Polyethylene Pressure Drop per 100ft of Pipe
Antifreeze (30°F [-1°C] EWT): 25% Ethanol by volume solution - freeze protected to 15°F [-9.4°F]

Flow Rate	3/4" IPS SDR11			1" IPS SDR11			1-1/4" IPS SCH40			1-1/2" IPS SCH40			2" IPS SCH40		
	PD (ft)	Vel (ft/s)	Re	(ft)	Vel (ft/s)	Re	PD (ft)	Vel (ft/s)	Re	PD	Vel (ft/s)	Re	PD	Vel (ft/s)	Re
1	0.37	0.55	1013	0.13	0.35	807	0.04	0.21	620	0.02	0.16	551	0.01	0.10	442
2	1.26	1.10	2025	0.43	0.70	1614	0.13	0.43	1270	0.06	0.32	1103	0.02	0.19	841
3	2.55	1.66	3056	0.88	1.06	2444	0.27	0.64	1891	0.13	0.47	1620	0.04	0.29	1283
4	4.22	2.21	4068	1.45	1.41	3251	0.45	0.86	2540	0.21	0.63	2171	0.07	0.38	1681
5	6.24	2.76	5081	2.14	1.76	4058	0.66	1.07	3161	0.32	0.79	2723	0.10	0.48	2124
6	8.58	3.31	6093	2.95	2.11	4864	0.91	1.29	3811	0.44	0.95	3274	0.13	0.57	2522
7	11.23	3.87	7124	3.86	2.47	5694	1.19	1.50	4431	0.57	1.10	3791	0.17	0.67	2964
8	14.19	4.42	8137	4.87	2.82	6501	1.50	1.72	5081	0.72	1.26	4342	0.22	0.76	3363
9	17.44	4.97	9149	5.99	3.17	7308	1.85	1.93	5701	0.89	1.42	4894	0.27	0.86	3805
10	20.97	5.52	10162	7.20	3.52	8115	2.22	2.15	6351	1.07	1.58	5445	0.33	0.96	4248
11	24.77	6.08	11193	8.51	3.87	8922	2.62	2.36	6972	1.26	1.73	5962	0.38	1.05	4646
12	28.85	6.63	12205	9.91	4.23	9752	3.05	2.57	7592	1.47	1.89	6514	0.45	1.15	5088
13				11.40	4.58	10559	3.51	2.79	8242	1.69	2.05	7065	0.52	1.24	5487
14				12.98	4.93	11366	4.00	3.00	8862	1.92	2.21	7616	0.59	1.34	5929
15				14.64	5.28	12173	4.51	3.22	9512	2.17	2.36	8133	0.66	1.43	6327
16				16.39	5.64	13003	5.05	3.43	10132	2.43	2.52	8685	0.74	1.53	6770
17				18.23	5.99	13810	5.61	3.65	10782	2.70	2.68	9236	0.82	1.63	7212
18				20.15	6.34	14616	6.21	3.86	11403	2.98	2.84	9788	0.91	1.72	7610
19				22.15	6.69	15423	6.82	4.08	12052	3.28	2.99	10305	1.00	1.82	8053
20				24.23	7.04	16230	7.46	4.29	12673	3.59	3.15	10856	1.10	1.91	8451
21				26.38	7.40	17060	8.13	4.50	13293	3.91	3.31	11407	1.19	2.01	8893
22				28.62	7.75	17867	8.82	4.72	13943	4.24	3.47	11959	1.29	2.10	9292
23				30.94	8.10	18674	9.53	4.93	14563	4.58	3.62	12476	1.40	2.20	9734
24							10.27	5.15	15213	4.94	3.78	13027	1.51	2.29	10132
25							11.03	5.36	15834	5.30	3.94	13579	1.62	2.39	10575
26							11.81	5.58	16483	5.68	4.10	14130	1.73	2.49	11017
28							13.44	6.01	17754	6.47	4.41	15198	1.97	2.68	11858
30							15.17	6.44	19024	7.29	4.73	16301	2.23	2.87	12699
32							16.99	6.86	20265	8.17	5.04	17370	2.49	3.06	13539
34							18.89	7.29	21535	9.08	5.36	18473	2.77	3.25	14380
36							20.87	7.72	22805	10.04	5.67	19541	3.06	3.44	15221
38							22.95	8.15	24075	11.03	5.99	20644	3.37	3.63	16061
40							25.10	8.58	25346	12.07	6.30	21712	3.68	3.82	16902
42							27.34	9.01	26616	13.14	6.62	22815	4.01	4.02	17787
44							29.65	9.44	27886	14.26	6.93	23883	4.35	4.21	18628
46										15.41	7.25	24986	4.70	4.40	19468
48										16.60	7.57	26089	5.07	4.59	20309
50										17.83	7.88	27157	5.44	4.78	21150

Pressure Drop

Table 6d: Polyethylene Pressure Drop per 100ft of Pipe
No Antifreeze (50°F [10°C] EWT): Water

Flow Rate	3/4" IPS SDR11			1" IPS SDR11			1 1/4" IPS SCH40			1 1/2" IPS SCH40			2" IPS SCH40		
	PD (ft)	Vel (ft/s)	Re	PD (ft)	Vel (ft/s)	Re	PD (ft)	Vel (ft/s)	Re	PD (ft)	Vel (ft/s)	Re	PD (ft)	Vel (ft/s)	Re
1	0.23	0.55	2,806	0.08	0.35	2,241	0.02	0.21	1,724	0.01	0.16	1,508	0.00	0.10	1,160
2	0.78	1.10	5,612	0.27	0.70	4,481	0.08	0.43	3,447	0.04	0.32	3,016	0.01	0.19	2,320
3	1.59	1.66	8,418	0.54	1.06	6,722	0.17	0.64	5,171	0.08	0.47	4,525	0.02	0.29	3,481
4	2.62	2.21	11,224	0.90	1.41	8,963	0.28	0.86	6,895	0.13	0.63	6,033	0.04	0.38	4,641
5	3.88	2.76	14,030	1.33	1.76	11,203	0.41	1.07	8,618	0.20	0.79	7,541	0.06	0.48	5,801
6	5.34	3.31	16,836	1.83	2.11	13,444	0.56	1.29	10,342	0.27	0.95	9,049	0.08	0.57	6,961
7	6.99	3.87	19,642	2.40	2.47	15,684	0.74	1.50	12,066	0.36	1.10	10,558	0.11	0.67	8,121
8	8.83	4.42	22,448	3.03	2.82	17,925	0.93	1.72	13,789	0.45	1.26	12,066	0.14	0.76	9,281
9	10.85	4.97	25,254	3.73	3.17	20,166	1.15	1.93	15,513	0.55	1.42	13,574	0.17	0.86	10,442
10	13.05	5.52	28,060	4.48	3.52	22,406	1.38	2.15	17,237	0.66	1.58	15,082	0.20	0.96	11,602
11	15.41	6.08	30,866	5.30	3.87	24,647	1.63	2.36	18,960	0.78	1.73	16,590	0.24	1.05	12,762
12	17.95	6.63	33,672	6.16	4.23	26,888	1.90	2.57	20,684	0.91	1.89	18,099	0.28	1.15	13,922
13				7.09	4.58	29,128	2.18	2.79	22,408	1.05	2.05	19,607	0.32	1.24	15,082
14				8.07	4.93	31,369	2.49	3.00	24,132	1.20	2.21	2,115	0.36	1.34	16,242
15				9.11	5.28	33,609	2.81	3.22	25,855	1.35	2.36	22,623	0.41	1.43	17,403
16				10.20	5.64	35,850	3.14	3.43	27,579	1.51	2.52	24,132	0.46	1.53	18,563
17				11.34	5.99	38,091	3.49	3.65	29,303	1.68	2.68	25,640	0.51	1.63	19,723
18				12.53	6.34	40,331	3.86	3.86	31,026	1.86	2.84	27,148	0.57	1.72	20,883
19				13.78	6.69	42,572	4.24	4.08	32,750	2.04	2.99	28,656	0.62	1.82	22,043
20				15.07	7.04	44,813	4.64	4.29	34,474	2.23	3.15	30,164	0.68	1.91	23,203
21				16.41	7.40	47,053	5.06	4.50	36,197	2.43	3.31	31,673	0.74	2.01	24,364
22				17.80	7.75	49,294	5.48	4.72	37,921	2.64	3.47	33,181	0.81	2.10	25,524
23				19.25	8.10	51,534	5.93	4.93	39,645	2.85	3.62	34,689	0.87	2.20	26,684
24							6.39	5.15	41,368	3.07	3.78	36,197	0.94	2.29	27,844
25							6.86	5.36	43,092	3.30	3.94	37,706	1.01	2.39	29,004
26							7.35	5.58	44,816	3.53	4.10	39,214	1.08	2.49	30,164
28							8.36	6.01	48,263	4.02	4.41	42,230	1.23	2.68	32,485
30							9.44	6.44	51,710	4.54	4.73	45,247	1.38	2.87	34,805
32							10.57	6.86	55,158	5.08	5.04	48,263	1.55	3.06	37,125
34							11.75	7.29	58,605	5.65	5.36	51,280	1.72	3.25	39,446
36							12.99	7.72	62,053	6.24	5.67	54,296	1.91	3.44	41,766
38							14.27	8.15	66,500	6.86	5.99	57,312	2.10	3.63	44,086
40							15.61	5.58	68,947	7.51	6.30	60,329	2.29	3.82	46,407
42							17.01	9.01	72,395	8.18	6.62	63,345	2.49	4.02	48,727
44							18.45	9.44	75,842	8.87	6.93	66,362	2.71	4.21	51,047
46							19.94	9.87	79,289	9.59	7.25	69,378	2.93	4.40	53,368
48										10.33	7.57	72,395	3.15	4.59	55,688
50										11.09	7.88	75,411	3.39	4.78	58,009

Pressure Drop

Table 6e: 1" Rubber Hose Pressure Drop per 100ft of Hose No Antifreeze (50°F [10°C] EWT): Water

Flow Rate	Methanol*			Propylene Glycol*			Ethanol*			Water*		
	PD (ft)	Vel (ft/s)	Re	PD (ft)	Vel (ft/s)	Re	PD (ft)	Vel (ft/s)	Re	PD (ft)	Vel (ft/s)	Re
1	0.12	0.35	895	0.14	0.35	507	0.13	0.35	807	0.12	0.35	923
2	0.42	0.70	1789	0.48	0.70	1013	0.43	0.70	1614	0.42	0.70	1847
3	0.85	1.06	2709	0.98	1.06	1534	0.88	1.06	2444	0.85	1.06	2796
4	1.41	1.41	3604	1.63	1.41	2041	1.45	1.41	3251	1.40	1.41	3720
5	2.09	1.76	4499	2.41	1.76	2548	2.14	1.76	4058	2.07	1.76	4643
6	2.87	2.11	5393	3.31	2.11	3054	2.95	2.11	4864	2.85	2.11	5567
7	3.76	2.47	6314	4.33	2.47	3575	3.86	2.47	5694	3.73	2.47	6516
8	4.75	2.82	7208	5.47	2.82	4082	4.87	2.82	6501	4.71	2.82	7440
9	5.84	3.17	8103	6.73	3.17	4589	5.99	3.17	7308	5.79	3.17	8363
10	7.02	3.52	8997	8.09	3.52	5095	7.20	3.52	8115	6.96	3.52	9286
11	8.29	3.87	9892	9.56	3.87	5602	8.51	3.87	8922	8.23	3.87	10210
12	9.65	4.23	10812	11.13	4.23	6123	9.91	4.23	9752	9.58	4.23	11160
13	11.11	4.58	11707	12.80	4.58	6630	11.40	4.58	10559	11.02	4.58	12083
14	12.65	4.93	12602	14.58	4.93	7136	12.98	4.93	11366	12.55	4.93	13006
15	14.27	5.28	13496	16.45	5.28	7643	14.64	5.28	12173	14.16	5.28	13930
16	15.97	5.64	14416	18.41	5.64	8164	16.39	5.64	13003	15.85	5.64	14879
17	17.76	5.99	15311	20.48	5.99	8670	18.23	5.99	13810	17.62	5.99	15803
18	19.63	6.34	16206	22.63	6.34	9177	20.15	6.34	14616	19.48	6.34	16726
19	21.58	6.69	17100	24.88	6.69	9684	22.15	6.69	15423	21.41	6.69	17650
20	23.61	7.04	17995	27.22	7.04	10190	24.23	7.04	16230	23.42	7.04	18573

*Notes:
1. Methanol is at 20% by volume; propylene glycol is at 25% by volume; ethanol is at 25% by volume.
2. Percentage by volume, shown above is 15°F [-9.4°C] freeze protection.
3. All fluids with antifreeze are shown at 30°F [-1°C]; water is at 50°F [10°C].

Site Survey Form

Client Name: ______________________________ Date: ______________________________

Address: ______________________________ Surveyed by: ______________________________

Phone: ______________________________ ❑ New construction ❑ Retrofit

GeoDesigner performed by: ____________________ Phone: ______________ Date: __________

Soil conditions: ____

Special conditions and requirements: ____

____

Permit number: ____________ Owner's preference on location of loop: ____________________

____

Locate property lines, existing structures, future construction, utilities, and services. Also locate the geo unit, earth loop, penetration etc.

Scale 1 small square = __________ ft.

N

Power Lines
- ❑ overhead
- ❑ underground

Telephone Lines
- ❑ overhead
- ❑ underground

TV Cable
- ❑ overhead
- ❑ underground

❑ Water Well
Depth _______ ft.

❑ City Water

❑ Natural Gas

❑ Propane

❑ City Sewer

❑ Private Sewer

❑ Easements

❑ Fuel Lines

❑ Lawn Sprinkler

❑ Drain Tile

❑ Bldg. Penetration

❑ Unit location

❑ Existing condensing unit

❑ Pond
Size ___________
Avg. Depth _______
Min. Depth _______

❑ Other ____________

Notes

Revision History

Date	Page #	Description
12 June, 09	All	Updated Table 3d: Polyethylene Pressure Drop
20 May, 09	26	Information in Pressure Drop Table (Table 6d) Replaced
05 June, 08	All	Reformatted Document Size
03 Mar, 08	26	Updated Table
01 Oct, 08	All	First Published

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